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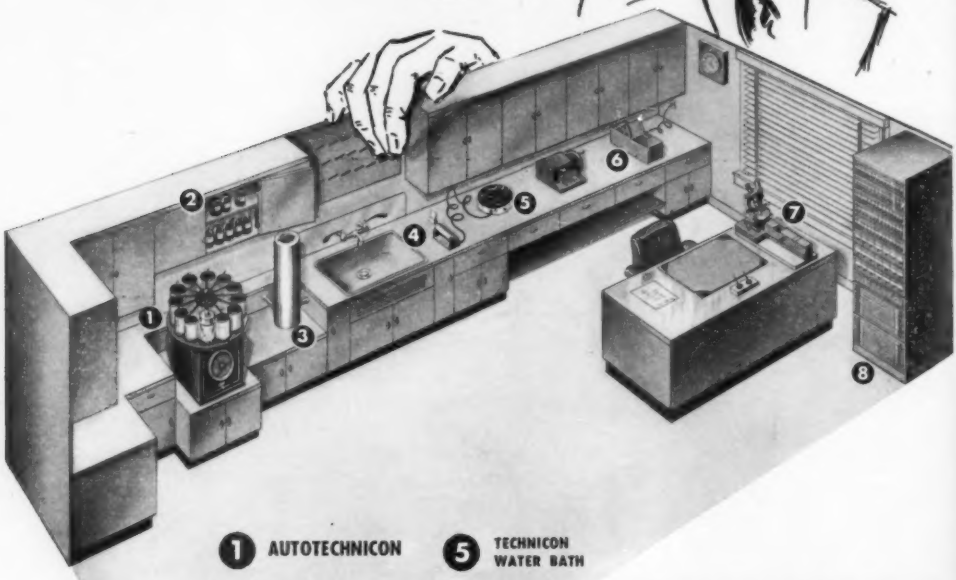

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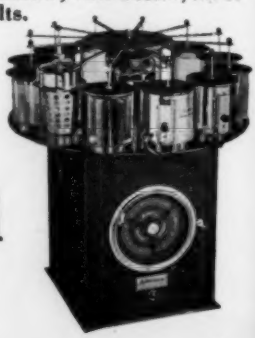

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The Study of Child Development

THE philosophy—as well as the purpose—of the study of child development may be summed up as follows: *A well-born and a well-reared child is a community asset; anything less is a liability.* There are two basic concepts here that are complementary. "Well-born" means that it should be the birthright of every child to come into the world as free as possible of heritable taint and congenital defect. "Well-reared" means that it should be the privilege of every child to grow up under the best possible environmental conditions. If the child's biogenetic endowment is sound, then it should be nourished in the fertile soils of human love and cultural richness. The realization of this vision entails the study of the whole bio-behavioral child in the entire context of his familio-cultural milieu. We may paraphrase: "A sound *unfolding* mind in a sound *growing* body"—to which we might add, "in a sound and stable *environment.*"

It has been said that we grow, we grow up, we grow older. In more concrete terms this implies increase in size, change in proportion, and organic maturation. In a very real sense, therefore, the study of the entire process must embrace the realms of morphology, physiology, biochemistry, and endocrinology. This effectively covers the biological side of the picture. The behavioral side must include the educative process and social and psychological aspects in the broadest possible manner. The concept "the growth of the whole child," as commonly stated, embraces consideration of every possible variable in and of the growing period, roughly the first two decades of life.

There is one thing common in assessing these variables: they must be quantified; i.e., they must be measured or be made measurable. In this process of multimeasuring there are five aims: (1) to ascertain *status,* at any one time; (2) to evaluate *progress* between two or more periods of time; (3) to compare either status or progress to *standards* for age and sex peers; (4) to fit the child's growth into the potential inherited in *family-line* background; (5) to add all this up to a final analytic interpretation of the *individual pattern.* In basic principle, although we study hundreds of children, we ultimately focus upon one child at a time, especially if this growth is of clinical concern.

We have discarded the old idea of extensive cross-sectional norms or averages (100 boys and girls at birth, 100 at one year, at two years, and so on). Instead, we take a sample for a much more intensive serial or longitudinal analysis. We march with them in time, year after year. The averages we derive are, in reality, the expression of so many individual paths of growth. An important result of this approach has been to free the individual child from the slavish adherence to arbitrary height-weight standards, or other rigid norms of bodily development. Thus we no longer force the child to walk the straight and narrow path of the mean; rather, we permit him to saunter, as his own growth potential will, along the broad highway of an acceptable range of variability. For stature and weight, for example, we have adopted the principle of fitting the individual child into a family line of tall, medium, or short; heavy, medium, or light—feeling that the child will almost invariably reflect an inherited height-weight trend.

One final word must be said: we are studying normal, healthy children in our long-term programs. We are studying them from every possible biological and cultural angle, putting the results together for one common goal: that tomorrow's children may have life more abundantly, because we are learning from today's children.

WILTON MARION KROGMAN
Graduate School of Medicine
University of Pennsylvania

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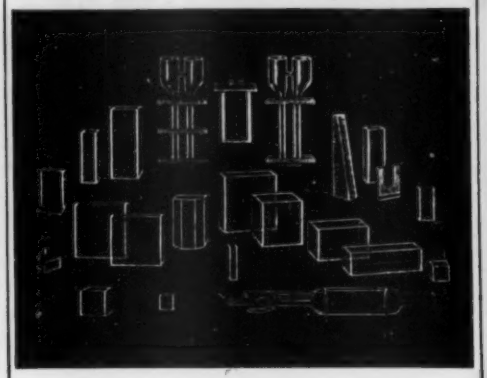

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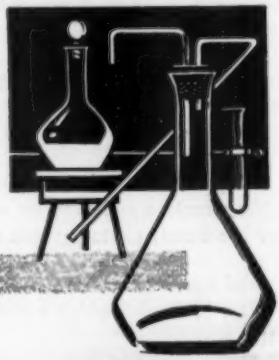

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Summary of 1952 Elastomer Conference, Gordon Research Conferences[1]

J. D. D'Ianni

Research and Development Division, The Goodyear Tire & Rubber Company, Akron, Ohio

AN Elastomer Conference was held at Colby Junior College, New London, New Hampshire, June 30–July 4, as part of the 1952 Gordon Research Conferences sponsored by the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. J. D. D'Ianni served as chairman, and M. Morton (Akron University) as vice-chairman. The program consisted of the presentation of a series of formal papers, followed by discussion led by selected participants. Fields covered were: emulsion polymerization, physical properties of latex, dynamic properties of rubber, crystallization phenomena and structural effects, chemistry of vulcanization, and degradation studies. Discussion leaders included W. V. Smith (U. S. Rubber), J. A. Davison (U. S. Rubber), H. L. Williams (Polymer Corporation), J. A. Yanko (B. F. Goodrich), J. Rehner, Jr. (Esso Laboratories), R. Buchdahl (Monsanto), A. W. Meyer (U. S. Rubber), A. M. Bueche (General Electric), D. Craig (B. F. Goodrich), C. M. Doede (Connecticut Hard Rubber), and J. O. Cole (Goodyear). The ensuing brief report of the significant results discussed at this conference is based largely on the exact wordage of summaries kindly supplied by each speaker.

Two papers were presented in the field of emulsion polymerization. E. J. Meehan (University of Minnesota) described new redox systems for the emulsion copolymerization of butadiene and styrene. One of the new systems makes use of the reaction between chromium (VI) and arsenic (III) in slightly alkaline (soap) medium to produce free radicals that initiate polymerization. This system is suitable for use at temperatures of 20°–40° C. Other new redox systems, developed for use at temperatures around 0° C, make use of the reaction between an iron (II) complex and an organic hydroperoxide to produce free radicals. The concentration of iron (II) in the system is maintained at a suitable value by the addition of a reducing agent, which continually reduces the iron (III) formed in the rapid reaction of iron (II) with the hydroperoxide. Hydrazine and sodium sulfide were found suitable reductants when ethylene diamine tetracetate was the complexing agent for iron. Studies on the mechanism of initiation of emulsion polymerization by persulfate were also reviewed and discussed.

M. Morton, in polymerization studies with chloroprene, found that the soap micelles are not the only important locus of formation of particles. Both the aqueous phase and the oil-water interface appear capable of initiating polymer particles, as evidenced by the marked effect of agitation on the polymerization rate. The presence of these additional loci of polymerization appears to be due to the exceptional reactivity of this monomer rather than to its solubility in water, which is relatively low.

In the symposium on the physical properties of latex, E. G. Cockbain (British Rubber Producers' Research Association) stated that the mechanism of the reversible aggregation of latex and synthetic emulsion particles depends on the nature of the adsorbed film stabilizer. If this is a soap or synthetic detergent, adsorption is no longer monomolecular when the soap concentration in the aqueous phase is appreciably greater than the critical micellar concentration. A secondary adsorbed layer of soap or detergent is believed to be formed, with the hydrocarbon chains oriented toward the aqueous phase, thereby rendering the surface of the disperse phase hydrophobic and causing aggregation. In systems stabilized by proteins, the pH and the ionic strength of the aqueous phase are the main factors controlling particle aggregation. In the presence of soaps or proteins and an additional hydrophilic colloid such as sodium alginate, secondary adsorption of the hydrophilic colloid probably occurs, leading to an interlinking of particles of the disperse phase.

The coalescence of latex or synthetic emulsion particles on heating in the presence of an organic heat-sensitizing agent such as polyvinylmethyl ether depends on both the interfacial activity and the negative temperature coefficient of solubility of the ether. Adsorption of the sensitizing agent on the rubber particles appears to be necessary for effective heat sensitization. To prevent the preferential adsorption of fatty acid soaps present in latex, the interfacial activity of the soaps may be reduced by a lowering of pH, addition of polyvalent cations, or similar means. Organic heat-sensitizing agents other than polyvinylmethyl ether were described, including the polyoxyethyleneoxypropylene diols. Suitable agents of this class show considerable promise as heat-sensitizing agents for natural latex.

The second paper on latex, by S. H. Maron (Case Institute of Technology), was a summary paper on

[1] Work discussed herein by E. J. Meehan, M. Morton, S. H. Maron, T. W. DeWitt, R. M. Pierson, W. S. Richardson, H. E. Adams, and I. Auerbach was performed as part of research projects sponsored by the Reconstruction Finance Corporation, Office of Synthetic Rubber, in connection with the government synthetic rubber program.

"Determination of Synthetic Latex Particle Size and its Distribution." The methods for particle size determination discussed were electron microscopy, soap titration, and light scattering, in which were included dissymmetry, wavelength exponent variation, and minimum intensity of scattering. Each method was considered from the standpoint of the experimental techniques involved and its advantages and limitations. Maron also gave a procedure by means of which it is possible to determine the particle size distribution of a latex from suitable differential creaming data.

The next topic for discussion was "Dynamic Properties—Effect of Molecular Weight and other Parameters." The first paper, entitled "Shear Dynamics in the Rubbery State," was presented by I. L. Hopkins (Bell Telephone Laboratories). T. W. DeWitt (Mellon Institute) summarized "Some Dynamic Studies on Fractions of Diene Polymers." A major objective of this program was the study of the relation between the structure and physical properties of synthetic elastomers. The response of the rubber to slow alternating stresses (0.0005–0.5 cps) was used as the basis of comparison. Insofar as possible, fractions of approximately the same molecular weight (200,000) were used in an effort to eliminate the effect of molecular weight and molecular weight distribution.

Four materials were surveyed for their behavior over a wide temperature range (−60° C to +100° C) and at several frequencies. Two polybutadienes, one prepared at 5° C and one at 50° C, and two butadiene-styrene copolymers, one with about 27 per cent styrene and one with about 15 per cent styrene, both prepared at 5° C, were thus studied. A very brief survey in the neighborhood of room temperature was also made of polybutadiene prepared at −20° C. The outstanding differences between these materials are found in the low temperature region. The temperature of maximum loss—and most rapid rise in modulus—is higher, the higher the styrene content. Crystallization, which occurs with the 5° C and −20° C polybutadiene, is accompanied by a decrease in the loss and an increase in the modulus—a relationship the reverse of that usually encountered.

Surprisingly enough, the three polybutadienes and two butadiene-styrene copolymers show little difference in their behavior at room temperature. For two of the polybutadienes fractions of different molecular weights were studied. Increased molecular weight leads to a decrease in loss and an increase in modulus. The effect of molecular weight appears to be at least as great as that of structural differences in the room temperature region. A comparison of these data with somewhat more complete data for high molecular weight polyisobutylene shows the somewhat unexpected result that, in the region of room temperature, this material has a much lower loss factor. A polyisobutylene of about the same molecular weight but an appreciably lower modulus is not strikingly different in loss factor from the diene polymers studied. Natural rubber was not studied, but data from the literature indicate that it is similar to high molecular weight polyisobutylene in its room temperature behavior.

R. M. Pierson (Goodyear) described some recent work correlating free-end fraction and resilience. Elastomer networks, the free-end fractions of which were varied over wide limits, were composed as to dynamic properties, particularly resilience. The free-end fraction, $\frac{2Mc}{Mn+Mc}$, was manipulated by varying either Mc, the molecular weight between cross-links, or Mn, the primary number average molecular weight. Dynamic resilience properties of each of the elastomers studied—principally "cold" GR-S and natural rubber—dropped markedly as the free-end fraction was increased above 10–15%. Since practical processing techniques require operation within rather narrow limits of the weight average molecular weight, Mw, the desirability of utilizing polymers of low ratios of Mw/Mn (narrow distribution) for maximum resilience properties was brought out.

The first paper in the section on crystallization phenomena and structural effects was by W. B. Reynolds (Phillips Petroleum) on "Hydrogenated Polymers." Hydrogenation of synthetic elastomers, such as polybutadiene and copolymers of butadiene with various vinyl compounds, produces a group of thermoplastic resins possessing interesting properties. These materials resemble polyethylene but are generally more flexible, particularly at very low temperatures. For example, hydrogenated polybutadiene can be struck sharply at −100° F without shattering, and is not brittle (even though extremely hard) at liquid nitrogen temperatures.

Hydrogenation can be carried to various stages, depending upon the properties desired. For most plastic applications an unsaturation of 5–30 per cent of the original is desirable. Higher unsaturations increase the ability of the products to undergo vulcanization. Some of the more important potential applications for hydrogenated polymers are in wire and cable coating, films, tubing, and various molded items. These hydrogenated high polymers are now in the development stage in a program that has been supported in part by the Office of the Quartermaster General.

W. S. Richardson (Mellon Institute) summarized "The Influence of Polymerization Conditions on the Structure of Diene Polymers," reviewing the microstructure of polyisoprenes and polybutadienes prepared in bulk and emulsion systems between −20° and 100° C. The general features of the structure of alkali metal and alfin polymers were also briefly mentioned. New work was reported on three groups of polymers: polymers prepared in bulk between room temperature and about 300° C, polymers prepared at room temperature in bulk under high hydrostatic pressures, and polymers prepared between −80° C and +40° C in solution using Friedel-Crafts catalysts.

The resulting polymer structures as obtained from infrared spectra show that, as the preparation tem-

perature is raised, the polybutadienes tend toward roughly equal *cis-* and *trans-*concentrations (40 per cent), the 1,2 addition concentration remaining about 20 per cent, as it is in lower temperature preparations. In the case of the polyisoprenes, the *cis-* 1,4 addition increases only up to 100°–125° C and then decreases gradually for higher temperatures. The 3,4 addition remains sensibly constant over the whole temperature range, but the 1,2 addition decreases at higher temperatures, being almost absent at 300° C. It is not known whether this means the 1,2 addition is not formed at higher temperatures or whether it is formed and subsequently used up in some side reaction.

Polyisoprenes and polybutadienes were prepared at about 5000, 8000, and 10,000 atmospheres. As far as structure is concerned, there appears to be little variation over this rather limited pressure range. The polyisoprenes are roughly comparable to atmospheric pressure polymers prepared at lower temperatures (−20° C). This does not seem to be true of the polybutadienes, which are more nearly comparable to slightly higher-temperature, atmospheric-pressure polymers as far as 1,2 and *trans-* 1,4 additions are concerned. Since we do not analyze for *cis-* 1,4 addition in the polybutadienes, it is not clear whether the remainder of these polymers is composed of *cis-* 1,4 addition or whether there are other types of structures (cyclics, etc.) present.

Cationic polymers of polybutadiene and polyisoprene were prepared at room temperatures, −30° C, and −80° C, in solution using various Friedel-Crafts catalysts (BF_3, $SnCl_4$, and $AlCl_3$). Although some linear addition is present in these polymers, they show generally a lack of unsaturation varying between 20 and 80 per cent. Within the linear polymer present, the distribution among external and internal types of additions appears to be similar to the free radical–type polymers. Two other papers in this section were presented by F. M. Rugg (Bakelite Division, UCC), on "Infrared Structural Studies of Polyethylene and Changes on Oxidation," and by M. L. Dannis (B. F. Goodrich), on "Plasticizers for Polyvinyl Chloride."

Three papers were included in a comprehensive and lively discussion of the "Chemistry of Vulcanization." B. C. Barton (U. S. Rubber) discussed "Mechanism of Sulfur Vulcanization of Rubber." In the accelerated reaction of sulfur with rubber, the yield of cross-links is dependent on the time and temperature of vulcanization and on the concentration of sulfur, accelerator, zinc oxide, and fatty acid. When the conditions necessary for the maximum yield of cross-links per unit of combined sulfur are met, a linear relationship exists between the number of cross-links and both combined sulfur and zinc sulfide formed in the vulcanization reaction.

Calculations based on the Wall equation relating equilibrium modulus to number of cross-links suggest that, when the conditions for a maximum yield of cross-links are met, one molecule of zinc sulfide is produced for each cross-link formed. The reactivity of various alkyl and alkylene and mono- and disulfides with natural rubber indicates that two types of reversion occur in natural rubber vulcanizates. The most common type occurs rapidly at normal curing temperatures and is due to rupture of alkylene disulfide cross-links.

H. E. Adams (Firestone) reported that the cross-linking of natural rubber vulcanizates, prepared by Captax accelerated sulfur cures, is directly proportional to the amount of soluble zinc present at a constant sulfur level. One cross-link is formed for each zinc atom added and every two sulfur atoms that combine with the rubber. Zinc sulfide is produced in the degradation reaction that destroys the cross-linking. I. Auerbach (Goodyear) discussed the mechanism by which mercaptobenzothiazole (MBT) accelerates vulcanization. Its course in the vulcanization process was followed by tagging it with radioactive sulfur. It was found that the zinc mercaptide of MBT is the initial product and that this compound reacts with sulfur in the presence of rubber to remove a hydrogen from the rubber and regenerate MBT. The rubber in this active form reacts with sulfur to produce a cross-linked polymer.

Discussion of "Degradation Studies" was initiated by R. Simha (New York University) with a detailed examination of the "Free Radical Mechanism of Degradation," followed by E. G. Cockbain's report of W. F. Watson's work on "The Cold Mastication of Rubber." The degradation whereby rubber is plasticized by cold-milling depends on an initial rupture of the rubber hydrocarbon into polymeric free radicals by the applied shearing forces. These free radicals recombine under nitrogen, a fact that explains the long-known observation of no plasticizing in an inert atmosphere. Oxygen readily attacks these free radicals and changes the eventual termination into a reaction not involving combination of polymeric radicals. The anomalous negative temperature coefficient of plasticization by cold-milling is explicable by the increasing viscosity and, hence, applied shear. The mechanism is critically tested by milling in nitrogen after addition of compounds likely to function, as does oxygen, by interfering with the secondary recombination after the primary mechanical scission. Forty-seven substances are listed as competing with recombination with varying efficiency, from mercaptans as effective as oxygen to substances, such as phenol, with only a detectable action. A similar mechanism applies to the cold-milling of synthetic rubbers. With certain substances, such as maleic anhydride and chloranil, the eventual radical termination involves the rubber molecules, giving branched or cross-linked rubbers.

The probable allylic structure of the radicals formed by rupture and their chemical activity toward the added compounds were discussed. The factors influencing efficient mastication, the function of peptizers, and degradation under other types of rapid deformation were considered according to the mechanical-rupture mechanism.

The program was concluded by a study of the "Oxidation of Neoprene," as reported by E. K. Gladding (Du Pont), who stated that oxidation of poly-2-chlorobutadiene (neoprene) and poly-2,3-dichlorobutadiene is accompanied by the formation of peroxidic materials, carbonyl compounds, acids, and acid chlorides. The acid chloride function is a characteristic oxidation product of these chlorine-substituted polymers, and experiments with model compounds show that it is formed from a configuration equivalent to two adjacent monomer units of the polymer. The colored products that form during neoprene oxidation are believed to consist of structures that can arise through polymerization (followed by elimination of HCl), of β-chloro-α, β-unsaturated carbonyl, or carboxylic acid intermediates formed by oxidation.

A Discussion of Photosynthesis

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ASPECTS OF PHOTOSYNTHESIS from the initial absorption of light to the ultimate syntheses were scrutinized by some 80 research workers of many scientific disciplines at Gatlinburg, Tennessee, October 29–November 1, 1952.[1] The free discussion that was encouraged at this meeting yielded many clues for further study of the photosynthetic process.

Light utilized in photosynthesis is absorbed by the several chlorophylls and bacteriochlorophylls, and by open chain tetraphyrolles and carotenoids of various organisms. The absorbed energy is transferred between molecules of these pigments, as determined by the molecular structures and permitted by the organization of the pigments in the grana. The energy is used to effect the chemical transfer of hydrogen from some molecule, such as water, to unidentified primary acceptors. The acceptors then transfer hydrogen to compounds formed during carbon dioxide fixation, probably both by known and still unknown enzymatic systems.

Energy level systems for porphins and tetrahydroporphins were considered as a basis for discussion of the spectroscopic properties of related, but less symmetrical, chlorophylls that are effective in photosynthesis (J. R. Platt, University of Chicago). Such molecules have a triplet level of energy lower than the first excited singlet level that gives rise to fluorescence emission. This triplet level, having a long life of the order of 10^{-4} seconds, is responsible for photochemical reactions. The separation between those two levels determines how much of the energy of the absorbed light is degraded and, therefore, is not available for chemical activation in photosynthesis. Unfortunately, no direct calculation of this separation is available. Estimates, based on the measured values for the levels of several other compounds, however, indicate that the quantity might be as small as 5–10 kcal. for chlorophyll (M. Kasha, Florida State University; Platt).

Another singlet level may lie very close to the fluorescent level, but transitions between the former and the ground level are not observed, since they would be of the forbidden N-II type. If such a level lies between the fluorescent singlet level and the lowest triplet level, radiationless transitions between the two would be facilitated and fluorescence weakened.

Attention next turned to some reversible photochemical changes of chlorophyll, which are probably related to the primary acts of photochemical reactions sensitized by chlorophyll *in vitro* and possibly of photosynthesis. It is known that the red absorption of oxygen-free solutions of chlorophyll in methanol is reduced when such solutions are illuminated with intense, visible light. When the light is extinguished, the solution very quickly returns to its original color.

Experiments were described in which chlorophyll was dissolved in a rigid solvent, at liquid-nitrogen temperatures (H. Linschitz, Syracuse University). Under these circumstances the color change was much more marked, but the time required for the dark reversal of the photochemical process was too short to measure. If certain quinones were added, the photoproduct was stable so long as the solvent remained rigid. If the solution was warmed, the original color of the chlorophyll returned instantly when the solvent glass melted. The absorption of the labile photoproduct of chlorophyll was much less than that of normal chlorophyll in the red and blue but had a marked maximum in the green. This photochemical reaction is possibly an oxidation of the chlorophyll

[1] The conference was supported by the National Science Foundation, the Office of Naval Research, and the Atomic Energy Commission. This report combines summaries for individual sessions, which were prepared by R. S. Livingston (University of Minnesota), E. Rabinowitch (University of Illinois), C. S. French (Carnegie Institution of Washington), F. Daniels (University of Wisconsin), B. Kok (Wageningen University), and M. Kamen (Washington University), who served as chairmen. Discussions were introduced by J. R. Platt (University of Chicago), E. C. Wassink (Wageningen University), R. Hill (University of Cambridge), M. Calvin (University of California, Berkeley), F. S. Brackett (National Institutes of Health), and H. Gaffron (University of Chicago).

resulting in formation of a semiquinone and of a corresponding oxidized chlorophyll radical.

Results of some recent experiments, in which solutions of chlorophyll in methanol were illuminated at room temperature with an intense light flash of short duration, were described (R. S. Livingston, University of Minnesota). The course of the back reaction that takes place in darkness was followed by the use of a photomultiplier and an oscilloscope. Analysis of data obtained by this method indicated that at least two different photolabile products are formed at comparable concentrations by the flash. One of these disappears by a first order reaction, or by a self-quenching process, with a half-life of almost 3×10^{-4} seconds, and reforms the normal molecule. About 20 per cent of the primary product forms a second labile product which has a spectrum similar to that observed in the rigid solvent at low temperatures. This product is probably a radical formed by a reaction of the primary product with a molecule of the solvent, since it reforms chlorophyll by a second order reaction.

The observation made by Krasnovskii that chlorophyll, when dissolved in liquid pyridine, is photoreduced by ascorbic acid has been verified (A. S. Holt, University of Illinois). Chlorophyll can be reformed in darkness from this reduction product by the addition of suitable oxidizing agents. The absorption spectrum of the reduced chlorophyll is similar to that of the reversible oxidation product of chlorophyll by quinones. Both resemble the absorption spectrum of "brown phase" of the Molisch phase test of chlorophyll.

The action spectra of fluorescence reveal the transfer of excitation energy between the several photosynthetic pigments ending in the pigment with the lowest excitation level (E. C. Wassink, Wageningen University). Measurements of fluorescence intensity of chlorophyll in plants and of bacteriochlorophyll in purple bacteria were considered as means of tracing the excitation energy, after this energy has been concentrated in the pigment with the lowest excitation level. This concept, however, was vigorously challenged. The fate in terms of "energy transfer" to an unknown chemical system was considered as one in which the electronic excitation energy is converted into chemical energy—e.g., of an oxidation-reduction system.

Recent experiments give new information about energy transfer between pigments. The action spectra of fluorescence in algae and purple bacteria demonstrate complete transfer of energy from chlorophyll *b* to chlorophyll *a*, and from the phycobilins in red and blue-green algae to chlorophyll *a*, and from two forms of bacteriochlorophyll (absorption maxima at 8000 A and 8500 A) to a third form—bacteriochlorophyll (8900 A) (T. M. N. Duysens, University of Utrecht). The energy transfer was found to be 40 per cent effective between carotenoids and bacteriochlorophyll in purple bacteria; complete between fucaxanthol and chlorophyll in brown algae; and only about 20 per cent effective between carotenoids and chlorophyll in red algae. These results closely parallel those obtained in the study of the action spectra of photosynthesis, thus proving that the latter is brought about exclusively by the excitation energy of chlorophyll *a* or of bacteriochlorophyll (8900 A) (C. S. French, Carnegie Institution; Duysens). The most interesting result is that this rule remains true even in those red or blue-green algae where a large part of chlorophyll *a* seems to be ineffective in producing either fluorescence or photosynthesis. In algae of this type, the energy absorbed by the red and blue pigments seems to be transferred to the small part of chlorophyll *a* that is present in fluorescent and photosynthetic form, but the larger part of chlorophyll *a* is useless because of contamination with a small amount of an unknown pigment—probably so-called chlorophyll *d*, which drains the excitation energy away and dissipates it through its own fluorescence. For some unknown reason, the contaminated chlorophyll *a* is unable to supply energy to the photosynthetic apparatus.

Reactivation of "inactive" chlorophyll *a* in red algae takes place with prolonged illumination by red or blue light, and renewed loss of activity follows illumination by green light (C. Yokum, Harvard). Extremely weak chemiluminescence that follows photosynthesis has a spectrum similar to that of chlorophyll *a* fluorescence (W. A. Arnold, Oak Ridge National Laboratory). The fluorescence is emitted whether photosynthesis is brought about by light absorbed by chlorophyll *a* itself, or by light absorbed by phycoerythrin, again confirming that the former pigment is the only one closely associated with the photochemical process in photosynthesis.

Absorption spectra of chlorophyll, bacteriochlorophyll, and their derivatives in microcrystalline form and in the form of monolayers on water give insight into the mechanism of energy transfer between identical molecules (E. E. Jacobs, University of Illinois). The results were interpreted as indicating that resonance interaction between closely packed pigment molecules produces shifts of the red absorption bands by 1500–2000cm^{-1} toward longer waves. The "red shift" in monolayers was about 90 per cent of that in three-dimensional microcrystals, indicating preferential resonance energy transfer in one plane. In microcrystals, the shift was found to be a function of crystal dimensions, becoming "saturated" in crystals containing 10^6 molecules. Theoretical discussions (H. Kallman, New York University, and others) showed that doubt remains as to the reliability of estimates of the extent of long-range transfer of energy between unlike molecules.

Although unknown steps remain in the energy transfer, the photochemical reacting system of the plastids can be followed *in vitro*, as was first accomplished by R. Hill (University of Cambridge) in 1938. Hill reported that the reaction rate is increased by a protein fraction of the cytoplasm for which

a partial concentrating has been accomplished. Rates of oxygen evolution have now been obtained that approach the rate of photosynthesis *in vivo*. A cellular fraction that promotes a high initial rate of reaction, even at low light intensities, was described (R. W. Lumry, University of Utah). The removal of this fraction enhanced the stability of the plastid preparation.

The lack of an induction period for the "Hill reaction" was shown by a methemoglobin reduction method that is free from the lags inherent in gas measurements (Hill). The properties of cytochrome *f*, present in plastids, and the possible participation of cytochrome *f* as an intermediate of photosynthesis were discussed. The hope is raised that the substance or chain of intermediates directly acted upon by energy transferred from chlorophyll *a* can be found.

The rate of oxygen evolution in the "Hill reaction" was found (Lumry and J. D. Spikes, University of Utah) to vary with light intensity in the form of a rectangular hyperbola. Extrapolation to zero light intensity indicated that between 6.7 and 8.2 quanta are required for production of one oxygen molecule. These values are markedly lower than those recently reported with quinone by O. Warburg.

That free radicals, such as HO_2 and OH, may take part in the early photoreactions was discussed (N. Uri, University of Chicago). These might be detected during photosynthesis by their catalytic effects on some polymerizations.

Interpretation of oxidation-reduction potential measurements under nonequilibrium conditions was discussed (D. Goddard, University of Pennsylvania; Rabinowitch, University of Illinois; and Uri). The way in which these measurements are widely used in biological work was challenged (Rabinowitch), and the confusion was traced to a failure to distinguish between the free energy change in a reaction, which determines the equilibrium, and a free energy of activation of an activated complex, which determines the rate.

The organization of the plastids was illustrated by electron micrographs (S. Granick, Rockefeller Institute for Medical Research; and A. E. Vatter, University of Illinois). The course of the formation of grana in higher plants, their platelike shape, and organization in lamellae were very clear, as was the presence of a membrane. Permeability of the membrane to various organic compounds can be followed by osmotic swelling (L. R. Blinks, Hopkins Marine Station; and J. H. McClendon, University of Minnesota).

The controversial subject of the minimum quantum requirement of photosynthesis was considered first from an experimental approach not dependent upon manometric measurements. A value of 6.5–8.0 quanta/O_2 was shown to be a minimum over short time periods above light compensation for respiration in a uniformly illuminated suspension of unstirred *Chlorella pyrenoidosa*. High initial values were not observed; instead, even under aerobic conditions, a brief induction period is noted during which the rate rises. In these experiments (F. S. Brackett and R. Olsen, National Institutes of Health), oxygen was determined by a polarographic method that permitted measurements at intervals of 10 seconds.

In measurement of quantum requirement a correction has to be made for respiration, which itself might be influenced by light. A mass spectrographic method (A. H. Brown, University of Minnesota) making use of O^{18} indicated that respiration was not stimulated in the light. This mass-spectrographic method had a time resolution of about one minute, the order of that for manometric methods (Riley, National Institutes of Health).

Polarographic measurements indicate systematic departures from monotonous changes in oxygen concentration during photosynthesis, similar to those of slower types found manometrically. These were eliminated when glucose was present. Similar changes were evident when pH was followed with a time resolution of seconds in photosynthetic algae suspensions (Gaffron, University of Chicago).

Measurements of minimum quantum requirements per oxygen molecule evolved by Warburg manometric methods still lead some investigators to results of 4 quanta or less (Burk, National Institutes of Health) and other investigators to 8 or more quanta (Emerson, University of Illinois). Thin algal suspensions and geometrically limited illumination are often, but not always, used by both groups of workers. Causes for differences in results apparently cannot be accounted for by intermittency of illumination or peculiarities of the algae. The report of marked effects upon algae of growth conditions, such as light intensity, however, might prove important (H. Tamiya, Tokugawa Institute).

Evidence for a lower quantum requirement below compensation for respiration by light was discussed (B. Kok, Wageningen University). While no marked changes were found in respiration at compensation by mass spectrographic methods (Brown), the fluctuations observed polarographically are of an order to explain the effect (Brackett, Olsen).

An initial photoreaction having a unit quantum requirement per molecule of oxygen was reported for *Chlamydomonas moewesii* in carbonate buffer (pH 8.8), as well as for chlorella in acid medium (Burk).

The over-all energy requirement for reduction of a mol of CO_2 to sugars by the photosynthetic system must be at least 184 kcal. (Franck, University of Chicago). Since the energy available from the triplet level of chlorophyll *a* is probably less than 36 kcal., at least 5 quanta/O_2 would be required. Fewer quanta might conceivably be required below compensation (or for short periods of time) if internal cycles existed for giving nonphoto-energy back into the CO_2 reduction (Franck; Kok; Strehler, Oak Ridge National Laboratory). The "Hill reaction,"

interestingly enough, might require only about 3.5 quanta/O^- in the limit, since entropy changes involved in atomic rearrangements are minor (Franck).

The course of carbon in photosynthesis is now understood in its major outline (Calvin, Benson, Bassham, *et al.*, University of California). Current experimental interest is moving toward solutions of the kinetics for accumulation of various compounds. The general technique is to add $C^{14}O_2$ at zero time to a photosynthesizing system and to determine the course of appearance with time of radioactivity in each carbon atom of metabolic intermediates. A method was given for solving the linear differential equations involved as carbon appears in more and more complex compounds, as the carbon course branches into several products, and as parts of molecules recycle toward the initial reactions.

Carbon first appears in the carboxyl group of phosphoglyceric acid PGA (Calvin *et al.*; Fager, University of Chicago). Since no probable two-carbon precursor of PGA has been found, attention is now turning to the possibility that CO_2 enters by addition to a more complex molecule. Time-activity curves for C^{14} incorporation indicate that the carboxyl carbon of PGA appears in the #5C of sedoheptulose and the #3C of the pentose. These compounds appear to be recycled back for the PGA initially formed upon fixation of CO_2.

The distribution of carbon in intermediate metabolic stages is influenced by inhibitors such as phenylurethane and dinitrophenol (Burris, University of Wisconsin). These inhibitors lead to a striking decrease in the relative C^{14} content of PGA to that of alanine after 30 seconds of photosynthesis. Sequence of light and dark periods and other changes also influence the distribution of C^{14} from $C^{14}O_2$ in the metabolic pools (S. Aronoff, Iowa State College).

Various approaches to the central problem of the mechanisms intervening between the light-absorption act and the appearance of reduced products of photosynthesis were considered (Gaffron). There are two broad assumptions: One holds that light absorption leads to the formation of a specific reductant unique to the photochemical system, with a unique reaction chain eventually coupling with the respiratory metabolism. The other holds that a nonspecific process gives rise to a multiplicity of reductants not unique to the photic metabolism but coupled directly to typical respiratory reaction chains.

Data presented may indicate that, during back reactions induced by photochemical oxygen, coupling with phosphorylation to form adenosine triphosphate and other forms of "high-energy" bonds occurs (Strehler). It is suggested that a number of quanta could cooperate in this fashion to produce an aggregate of such compounds, which by dismutation could raise one or more substances to a potential capable of CO_2 reduction. A number of experimental studies showing light-stimulated esterification of phosphate were presented (Wassink), as also were data on the existence of a phosphatase in extracts from green leaf material that is somewhat inhibited by light (Tamiya).

Experiments suggesting the existence of a new TPN-linked triose phosphate dehydrogenase were reported (D. Arnon, University of California). A partially purified preparation has been found to affect the apparent reversible oxidation of 3-phosphoglyceraldehyde without addition of either phosphate or arsenate. A number of alternative explanations, not involving the existence of a new enzyme, were developed in discussions of this report (M. Gibbs, Brookhaven National Laboratory; R. S. Bandurski, California Institute of Technology; and B. Vennesland, University of Chicago). Further purification of the system will probably lead to clarification of the phenomenon involved.

Data and experiments showing the versatility of the chloroplast suspensions in coupling reductively to a large variety of DPN- and TPN-linked systems while actively carrying out a "Hill reaction" were reviewed (W. Vishniac, Yale). The question of the significance of these observations on the nature of the natural hydrogen transfer system was considered (H. Gest, Western Reserve; S. Granick; E. Rabinowitch; and J. Rosenberg, University of Chicago). In this connection, the experiments attempting to isolate a protein fraction from the supernatant of centrifuged chloroplast suspensions which catalyzes the fixation of CO_2 in phosphoglycerate have been continued. As yet only small, albeit reproducible, fixations primarily in phosphoglycerate and phosphopyruvate have been observed with the partially purified preparations when added to chloroplast suspensions otherwise inactive in fixation (E. Fager, University of Chicago). The fixations that are observed, at present, appear to be inhibited by TPN, DPN, and ATP.

It was also reported that extracts of *R. rubrum* exhibit what is apparently the anaerobic analog to the "Hill reaction" of green plant extracts (Vernon, Kamen, Washington University). A light-sensitized oxidation of reduced cytochrome or indophenol accords with the inference that the other end of the reaction involves liberation of H_2 or its equivalent. The extracts fail to show any reduction capacity at present, but further efforts are being made to search out the reducing substances expected to be formed.

News and Notes

Scientists in the News

Henry K. Beecher, Henry I. Dorr professor of research in anesthesia, Harvard University, has been appointed honorary consultant to the Navy Surgeon General.

Detlev W. Bronk has been elected corresponding member of the Académie des Sciences, Paris.

Paul R. Burkholder, Eaton professor of botany at Yale University, and discoverer of the mold that contains chloromycetin, has received Dickinson College's annual Joseph Priestley Memorial Award.

Zenobio Cezero, of La Paz, Bolivia, recently visited the Atlantic Region Headquarters of the Topographic Division, U. S. Geological Survey.

Ronald Fisher, professor of genetics at the University of Cambridge, has arrived in Australia to consult with officers of the CSIRO Section of Mathematical Statistics and other research workers concerned with genetics and breeding investigations. He will visit several Australian cities, and deliver lectures to specialist audiences.

Don E. Francke, chief pharmacist at University Hospital, Ann Arbor, has been named recipient of the 1953 H. A. K. Whitney Lecture Award by the Michigan Society of Hospital Pharmacists, for contributions to the practice of hospital pharmacy.

O. H. Frankel, chief of CSIRO's Division of Plant Industry, Canberra, has been elected a fellow of the Royal Society, London, in recognition of his contributions to the theory of plant breeding.

Philip H. Groggins, who recently retired after 26 years with the Department of Agriculture and other federal agencies, has been appointed consulting editor of the *Journal of Agricultural and Food Chemistry,* a new publication of the American Chemical Society. Mr. Groggins will conduct a column called "The Observation Post" for the biweekly journal, in which he will discuss timely subjects in agricultural and food chemistry.

Fred G. Gronemeyer has been named assistant manager of the Chemstrand Corporation nylon plant under construction near Pensacola, Fla. Mr. Gronemeyer has been chief engineer of the Chemstrand nylon plant since its inception.

Walter R. Hibbard, Jr., has been appointed manager of the newly established Alloy Studies Section in the General Electric Research Laboratory's Metallurgy Research Department. Dr. Hibbard has been with GE since 1951.

Alberto Hurtado, professor of pathological physiology, Faculty of Medicine, and research director, Institute of Andean Biology, Lima, will give three lectures under the Edward K. Dunham Lectureship for the Promotion of the Medical Sciences, on "Natural Acclimatization to High Altitudes." The lectures will be given Apr. 21, 23, and 28, at the Harvard Medical School.

Kurt Ladenburg, formerly director of research and development at Schenley Laboratories, Inc., has been appointed director of research, development, and engineering at the Nepera Chemical Company.

Wingate A. Lambertson, of the Argonne National Laboratory staff, Chicago, has been named professor and research associate to the director of the Institute of Silicate Chemistry and Related Sciences, University of Toledo. **Arthur H. Black,** assistant professor of chemistry, was named assistant to the director.

Harold Lyons, research director of the National Bureau of Standards, was chosen to receive the annual award in the physical sciences, given by the Washington Academy of Sciences, for the discovery of a clock based on the vibrations of atoms.

Edward J. Massaglia has been appointed administrative vice president of all foreign trade subsidiaries of Chas. Pfizer & Co. Two other appointments were **Preston B. McGoodwin, Jr.,** vice president of Pfizer Inter-American, S. A., Laboratorios Pfizer, S. A., and Pfizer Canada, Ltd.; and **John O. Teeter,** vice president, Pfizer Overseas, Inc., and Pfizer, Ltd.

Raymond C. Maude, formerly director of communications, Headquarters, USAF, has assumed command of the Air Force Cambridge Research Center, Mass., a development and testing center of the Air Research and Development Command.

John M. Miller, Naval Research Laboratory, Washington, D. C., has received the Medal of Honor of the Institute of Radio Engineers, for his pioneering scientific and engineering contributions.

George A. Pierson, dean of students and professor of educational psychology at the University of Utah, has been appointed dean of students and director of student personnel at Queens College, effective July 1.

J. Ben Robinson, for 29 years dean of the Baltimore College of Dental Surgery, University of Maryland, has been appointed dean of the new School of Dentistry, West Virginia University, effective May 1.

Howard John Shaughnessey, director of Illinois State Public Health Laboratories, Chicago, will receive the annual award of the Society of Illinois Bacteriologists for his contributions to bacteriology.

Elwood B. Shirling, of Duke University, has been appointed assistant professor of botany at Ohio Wesleyan University, effective Sept. 1.

Ernest M. Weber, biochemist with Chas. Pfizer & Co. since 1942, has been appointed associate director of biochemical research and production.

James H. Wickersham has been elected president of Lenox Hill Hospital, New York, to succeed **William H. Zinsser.** Others elected were **F. M. E. Schaefer,** honorary vice president; **George W. Hill, Jr.,** and **Ethan A. Hitchcock,** vice presidents; and **George M. Schurman,** treasurer. **Jesse Knight** was re-elected secretary.

Donald H. Wilkins, of Park Rapids, Minn., a graduate student at the University of Illinois, has won a Merck Graduate Fellowship in Analytical Chemistry. Mr. Wilkins will continue his research at the university, where he is investigating the analysis of traces of metals that occur in plant and animal feeds.

Harold H. Williams, of Cornell University, has received the Borden Award in Nutrition, in recognition of his contributions on the vitamin components of human milk, and on nutritional and biochemical changes during lactation. **Vincent du Vigneaud,** of Cornell University Medical School, has received the Osborne and Mendel Award for work on the chemical structure, metabolic interrelations, and nutritional significance of essential dietary constituents.

Edgar Barton Worthington, secretary general of the Scientific Council for Africa South of the Sahara, has arrived in New York City for a five weeks' visit in the U. S. and Canada. Dr. Worthington coordinates the plans of six nations to raise the living standards of Africa through scientific development of resources.

Education

The **University of Arkansas,** in cooperation with the Arkansas Council of Teachers of Mathematics, will conduct a Workshop in Mathematics, July 13–15. Consultants will be Martha Hildebrandt, of Proviso Township High School, Maywood, Ill.; Maurice L. Hartung, of the University of Chicago; Christine Poindexter, of Little Rock; Virginia Sue Wilson, of the University of Arkansas. Inquiries should be addressed to D. P. Richardson, at Fayetteville.

The **University of Arkansas** School of Medicine is assured of the completion of its medical center in Little Rock by the recent action of the Arkansas General Assembly in allocating funds for the purpose. The first unit, a 450-bed teaching hospital and clinic, is under construction and will probably be finished in 1954. The entire center is expected to be completed in 1955.

Carnegie Arctic Scholarships will be provided by the Carnegie Corporation of New York for the McGill Geography Summer School (SCIENCE, 117, 271 [1953]). Twenty scholarships, each worth $100, will be awarded to residents in North America, and two of $250 each to overseas residents. In the event of a large number of suitable applications, the number of scholarships may be increased.

A **Committee on Educational Television,** supported by a grant of $25,000 from the Fund for Adult Education, will cooperate with the Joint Committee on Educational Television and the National Citizen's Committee for Educational Television. John C. Adams, of Hofstra College, is committee chairman, and the other members are Frederick L. Hovde, Samuel T. Arnold, Edgar Fuller, David D. Henry, Frederick G. Hochwalt, Mark C. Schinnerer, and L. A. Wilson.

The **University of Cincinnati** Graduate School of Arts and Sciences is planning a program of evening courses in the physical sciences, leading to the M.S. degree, beginning next September. Aeronautical, chemical, electrical, and mechanical engineering, chemistry, and physics will be offered.

Cook County Graduate School of Medicine will give a special course in cerebral palsy, limited to physicians only, June 15–26, under the direction of M. A. Perlstein. Applications should be sent directly to the registrar, 707 S. Wood St., Chicago 12.

Last April the **Federal Communications Commission** reserved 242 television channels for noncommercial educational television stations. No commercial applications will be considered until July 1. Up to the present time only 23 applications have been filed with the commission, although groups of educators and citizens are working to secure funds and explore program resources. In the hope that the time limit might be extended, the AAAS Board of Directors at its March 16 meeting, instructed E. U. Condon to write to each of the seven members of the FCC, urging that educational groups be given full opportunity after June 30 to take up channels originally set aside for educational purposes, so that "it will not be necessary for them to make precipitous decisions under undue pressures."

General Science Research Council in Denmark has distributed its first awards to Niels Bohr, Kaare Grønbech, Dr. phil. Bøggild, Ragnar Fjørtoft, Henrik Dam, Bengt Stromgren, Peter Skautrup, Niels Lassen, and Ole Munck, and Johs. Moutgaard. A grant of D. kr. 40,000 was allotted to publication of a report of the *Galathea* expedition and a sum of about D. kr. 100,000 was allocated for travel by many prominent Danish investigators for research of various kinds.

The **Nature Conservancy,** through the generosity of Conrad Chapman, of Boston, is offering a $500 scholarship for the year 1953–54 to candidates for the Ph.D. degree or its equivalent in a field that allows them to choose as a subject for the dissertation some aspect of the Relation of Human Population to Nature Conservation. Apply to the conservancy, 1840 Mintwood Pl., N. W., Washington 9, D. C., before *July 1.*

In the Laboratories

Battelle Memorial Institute has established a new technological information service for the preparation of bibliographies and coding and classification systems. Where required, the institute will undertake development of information-processing equipment. The service is the outgrowth of Battelle's experience in specific literature searching problems.

A new nonprofit corporation, **Protein Foundation, Incorporated,** will hold and administer patents covering important discoveries in the field of therapeutics and public health, will arrange for research and development work to make available laboratory discoveries of use to the medical profession, and will provide support for continuing basic research. Trustees of the foundation are Chester I. Barnard, James S. Adams, Detlev W. Bronk, Paul Foster Clark, W. K. Jordan, William M. Rand, and James Norman White.

Southwest Research Institute has opened building research laboratories in Princeton, N. J., following the decision of the John B. Pierce Foundation to concentrate its future activities in this field at its New Haven laboratories. Harry Tipper is supervisor of Southwest's building research laboratories.

Meetings and Elections

A **Conference on Instrumentation in Water, Sewage and Industrial Waste Treatment** will be held at Manhattan College, New York, May 14. The New York City Board of Water Supply and the Department of Public Works, with the cooperation of the Metropolitan Section of the Instrument Society of America and several companies in the instrument field, are sponsoring the meeting. Joseph McCabe, of the Manhattan Civil Engineering Department, is in direct charge.

The following have been appointed delegates to the **International Commission of Optics,** to be held in Madrid, Apr. 20–21: Brian O'Brien (chairman), Wallace R. Brode, and Deane B. Judd, voting delegates; Irvine C. Gardner, alternate; and Stanley S. Ballard, nonvoting delegate.

Mississippi State College will celebrate its 75th anniversary with a research symposium, Apr. 24–25. The following visitors will participate in the program: A. E. Ruark, G. A. Garratt, Frank J. Soday, F. O. Ringleb, H. N. Muller, Paul E. Klopsteg, Mace H. Bell, Kenneth R. Daniel, and Grover Loening.

Miscellaneous

The American Chemical Society has appointed the following new members to the advisory board of *Chemical and Engineering News* and *Industrial and Engineering Chemistry*: Harry L. Fisher, of the University of Southern California, and ACS president-elect; John R. Bowman, of Mellon Institute; John T. Cox, Jr., of Washington, D. C.; Robert F. Marschner, of Standard Oil (Ind.); and William A. Pardee, of Gulf Research & Development Company.

The **Botanical Society of America** has appointed a standing Committee on Education to continue to study the role and status of plant science and to promote improvement in the teaching of botany in American colleges and universities. It will advise and assist educational institutions in such matters, as well as on problems affecting the status of botany and botanists. Members of the committee are Sydney S. Greenfield, of Rutgers University, chairman; Harlan P. Banks, Vernon I. Cheadle, Ralph E. Cleland, Harriet B. Creighton, A. Orville Dahl, Victor A. Greulach, Irving W. Knobloch, and William C. Steere. The committee would be glad to receive comments and suggestions.

Underwritten by an anonymous gift of $52,500, the **Benjamin Franklin Magazine Awards** have been established at the University of Illinois. Eight annual awards will be given: for the most distinguished and meritorious public service during the year by an American magazine of general circulation, a gold medal and scroll, to be presented to the editor; for the most distinguished magazine writing involving original reporting in which serious obstacles had to be overcome, $1000 to the writer; and six other classifications carrying cash awards of $500 each. The program will be administered by a council, membership of which will include a representative of the public, representatives of the publishing and writing fields, and University of Illinois administrators.

Recent visitors from abroad at the **National Bureau of Standards** included B. M. Singh, Banaras Hindu University, India; Ivor T. Minhinnick and Ronald J. Atkinson, Farnborough, Eng.; F. L. Stumpers, Eindhoven, Netherlands; Jose Carvalho Alves da Costa, Portuguese West Africa; I. A. Shah, Lahore, Pakistan; Juichi Osawa, Yujiro Degawa, Enji Naito, Masuo Naito, and Hideo Itokawa, Tokyo; Pavel M. Domicelj, I. Pernat, A. S. Adum, B. V. Bezjak, R. I. Rodin, and S. M. Momcilovic, Yugoslavia; Ibrahim Abou Sinna, Cairo; and K. Y. Chen, Taiwan, Formosa.

New journals received: *Agricultural Research,* a magazine for agricultural leaders and workers. Publication bimonthly until July, when it will be made a monthly; $1.00 per year from the GPO after July. . . . *AO. Actualidades Odontolócicas.* Bimonthly; Año 1, No. 2, Nov.–Dec. 1952. Cr$ 30,00. Fôlha Odontológica Editôra S. A., São Paulo, Brazil. . . . *Comunicaciones del Instituto Tropical de Investigaciones Científicas.* Vol. 4, Oct. 1952. Universidad de El Salvador. . . . *Corning Glassmaker,* a new bimonthly publication of the Corning Glass Works, Corning, N. Y. Feb.–Mar. 1953. . . . *Civiltà delle Macchine.*

Bimonthly; Anno 1, No. 1, Jan. 1953 L. 2100 per year. Gruppo Industriale, Società Finanziaria Meccanica "Finmeccanica," Rome. . . . *Field Reporter,* Vol. I, No. 3, Nov.–Dec. 1952. Bimonthly, at $1.50 per year. Published by the Department of State, Washington, D. C., to provide information on educational, cultural, scientific, and technical phases of international cooperation. . . . *Journal of the Anatomical Society of India,* Vol. 1, No. 1, June 1952. Rs. 18 per year. Nilratan Sarkar Medical College, Calcutta. . . . *Mathematical Journal of Okayama University,* Vol. 1, Nos. 1–2, March 1952, in English, French, and German. The Department of Mathematics, Faculty of Science, will publish at least one volume yearly. . . . *Práctica Médica,* Revista Mensual de Divulgación Científica Post-Universitaria. Segunda Epoca, Año 1, No. 1, Jan. 1953. The universities of Madrid and Barcelona, Spain. . . . *Revista Ecuatoriana de Entomología y Parisitología.* Quarterly; Vol. I, No. 1, Jan. 1953. 100 sucres per year. Centro Ecuatoriano de Investigaciones Entomológiens, Guayaquil. . . . *Vital Notes on Medical Periodicals.* Vol. 1, No. 1, Oct. 1952, photostated. Florida State Board of Health, Jacksonville.

Princeton University Press took over the distribution of books published by the **National Bureau of Economic Research,** as well as its book publishing activities, on April 1. The bureau will continue to distribute its books directly to its contributors and subscribers, but orders from distributors, booksellers, individuals, and other book buyers will be filled by Princeton University Press.

Recent Deaths

John R. Ball (71) geologist, Seattle, Mar. 1; **Emil C. Barell** (79), chemist, of F. Hoffmann-La Roche and Co., Ltd., Basel, Mar. 17; **Benjamin S. Barringer** (75), urological surgeon, New Canaan, Conn., Mar. 14; **John H. Barrington** (84), authority on yeast, South River, N. J., Mar. 5; **Frederick W. Bartlett** (80), high vacuum expert, Chatham, Mass., Feb. 26; **Charles E. Beury** (73), educator, Philadelphia, Mar. 9; **George J. Bischof** (86), civil engineer, Brooklyn, N. Y., Feb. 25; **Albert F. Burgess** (79), entomologist, Brattleboro, Vt., Feb. 23; **Allen T. Burns** (77), social worker, Fort Myers, Fla., Mar. 9; **Douglas H. Campbell** (93), botanist, Palo Alto, Calif., Feb. 23; **Thomas S. Cullen** (84), gynecologist, Baltimore, Mar. 4; **Charles G. Curtis** (92), of New York, engineer and inventor, Central Islip, N. Y., Mar. 10; **Wilhelm Czermak** (63), Egyptologist, Vienna, Mar. 13; **Marc Daniels** (46), tuberculosis specialist, London, Mar. 3; **T. Carroll Davis** (71), ear, nose, and throat specialist, Philadelphia, Mar. 5; **Wray V. Drake** (52), chemist, Whittier, Calif., Feb. 27; **Theodore Bausch Drescher** (58), vice-president, Bausch & Lomb Optical Co., Rochester, N. Y. Feb. 22.

E. Van Norman Emery (62), psychoanalyst, St. Louis, Mar. 8; **Grosvenor S. Farmer** (103), physician, Watertown, N. Y., Mar. 12; **J. Wilson Furness** (79), mining engineer, Asheville, N. C., Mar. 4; **E. Noguera Gomez** (74), chemist, Caracas, Mar. 12; **Willard F. Greenwald** (56), research consultant, Woodmere, N. Y., Feb. 27; **Edwin B. Hart** (78), biochemist, Madison, Wis., Mar. 12; **George B. Haven** (81), machine design engineer, Gilford, N. H., Mar. 6; **Beatrice M. Hinkle** (78), psychoanalyst, New York, Feb. 28; **Francis W. Hirst** (79), economist, Singleton, Eng., Feb. 22; **Muriel Ivimey** (63), psychoanalyst, New York, Feb. 26; **Sigvald Johannesson** (75), civil engineer, Trenton, N. J., Feb. 22; **D. Forbes Keith** (—), refrigeration engineer, Fort Pierce, Fla., Mar. 10; **Arthur Kenner** (61), of Far Hills, N. J., electrical engineer, New York, Feb. 27; **William L. Kennon** (70), physicist and astronomer, Oxford, Miss., Dec. 4; **Otto Kestner-Cohnheim** (74), physiologist, Hamburg, Germany, Feb. 21; **Robert Kotze** (83), mining engineer, Capetown, S. A., Mar. 15.

Louis Launer (67), physician, Liberty, N. Y., Mar. 10; **James P. Lichtenberger** (82), sociologist, Philadelphia, Mar. 17; **James W. McBain** (70), chemist, Palo Alto, Calif., Mar. 12; **Morris A. Mason** (76), physician, New York, Mar. 4; **John D. Matheson** (73), civil engineer, Hawthorne, N. Y., Feb. 26; **Oliver F. Mershon** (79), eye specialist, Philadelphia, Feb. 22; **Howard C. Moloy** (50), obstetrician and gynecologist, New York, Mar. 13; **Austin Van Hoesen Mory** (83), chemical engineer, Amherst, Mass., Feb. 22; **Arthur R. Mosler** (82), engineer and inventor, New York, Feb. 27; **Elizabeth H. Muncie** (87), surgeon, Great Neck, N. Y., Mar. 15; **Holton V. V. Noyes** (82), agriculturist, Kenwood, N. Y., Mar. 16; **Wendell Paddock** (86), horticulturist, Columbus, Ohio, Feb. 19; **John D. Paul** (61), diabetes specialist, Philadelphia, Feb. 23; **Thomas I. Price** (70), hospital medical superintendent, Asbury Park, N. J., Mar. 5; **George R. Prout** (53), atomic physicist, Schenectady, N. Y., Mar. 8.

Garwood C. Richardson (56), obstetrician and gynecologist, Chicago, Mar. 4; **Joseph Rotundo** (45), economist, Schenectady, Mar. 9; **Gordon A. Ryrie** (52), authority on leprosy, Kirkcaldy, Scotland, Mar. 9; **Max Scheer** (69), of New York, dermatologist, Syracuse, N. Y., Mar. 1; **Major G. Seelig** (79), surgeon, Atherton, Calif., Mar. 11; **Hugh E. Setterfield** (52), anatomist, Columbus, Ohio, Mar. 16; **Jacob Skeer** (60), dermatologist, Brooklyn, Mar. 11; **O. L. Sponsler** (73), botanist, Los Angeles, Mar. 14; **Samuel Steiner** (77), of Philadelphia, physician, Broomall, Pa. Mar. 13; **Mortimer J. Stoddard** (78), physician, Springfield, Mass., Feb. 22; **Eliezer L. Sukenik** (64), archaeologist, Jerusalem, Feb. 28; **William E. Swift** (82), civil engineer, Harwinton, Conn., Feb. 28; **Jenoe E. Tausz** (68), research chemist, Newark, N. J., Feb. 19; **George H. Thompson** (76), physician and surgeon, Pittsfield, Mass., Mar. 8; **Albert B. Wells** (80), former chairman of the board, American Optical Co., San Diego, Mar. 3; **Sergei N. Winogradsky** (96), soil microbiologist, Brie-Comte-Robert, France, Feb. 24.

Technical Papers

On an Equation Specifying Equilibrium Populations

C. C. Li

Department of Biostatistics, University of Pittsburgh, Pittsburgh, Pennsylvania

Let x, $2y$, and z be the proportions of AA, Aa, and aa, respectively, in a population, where $x+2y+z=1$. It is well known that in a large random-mating population $x=p^2$, $2y=2pq$, and $z=q^2$, where p denotes the frequency of gene A and $q=1-p$ denotes that of a in the population. Hence the equation

$$xz-y^2=0 \tag{1}$$

specifies all panmictic populations (in equilibrium). Any population may be represented by a point P inside an equilateral triangle XYZ (Fig. 1), letting x, $2y$, and z be the perpendiculars from P to sides YZ, ZX, and XY, respectively; and $x+2y+z=$ altitude of the triangle, which we take as unity. Thus, the parabola (1) is the locus of points representing all panmictic populations (*1*).

Now consider a population with an inbreeding coefficient F which is defined as the (product-moment) correlation coefficient between uniting gametes (*2*). Here, $x=p^2+Fpq=(1-F)p^2+Fp$, $2y=2(1-F)pq$, and $z=q^2+Fpq=(1-F)q^2+Fq$. The parameter F is completely independent of the gene frequencies of a population. With any fixed value of F, the locus of these population points is obviously given by the parabola (*1*):

$$\left.\begin{aligned} &xz-y^2=F(x+y)(y+z) \\ \text{or}\quad &xz-y^2=\frac{y\cdot F}{1-F}. \end{aligned}\right\} \tag{2}$$

The primary purpose of this note is to put (1) and (2) in a new form which can be generalized to the case of multiple alleles, and to reveal the biological meaning of these equations. We note that x is the proportion of gene A existing in homozygous condition, whereas the total frequency of A in the population is $x+y=p$. Hence the proportion of A in homozygous condition among its total frequency is $x/(x+y)=x/p$. The above two equations of parabola are equivalent to

$$\frac{x}{x+y}+\frac{z}{y+z}=\frac{x}{p}+\frac{z}{q}=1 \tag{1'}$$

and

$$\frac{x}{x+y}+\frac{z}{y+z}=\frac{x}{p}+\frac{z}{q}=1+F, \tag{2'}$$

respectively. The new form (1') shows that, in panmictic populations, the sum of the proportions of genes existing in homozygous conditions among their own respective total frequencies is unity. It will be seen that this is a general theorem applicable to multiple alleles. When there is inbreeding in the population, the sum of such proportions will be in excess of unity by a mupltiple of F as shown in the following. It should also be noted that the second parabola (2') cuts the perpendiculars PQ from the first parabola to the base, ZX, so that the ratio $PP' : P'Q = F : 1-F$ (Fig. 1).

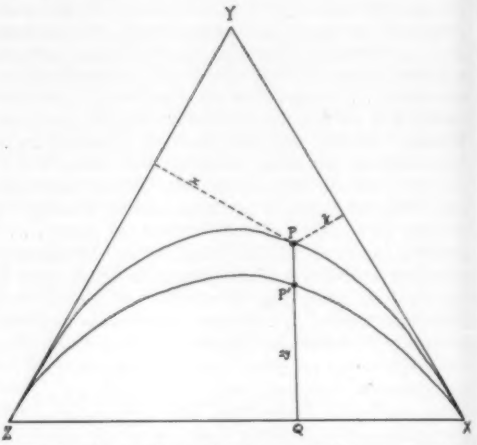

FIG. 1. The equations of the upper and lower parabolas are (1) and (2), respectively. Note that $ZQ : QX = p : q$ along the base and that $PP' : P'Q = F : 1-F$ along the projection PQ. (Modified from Haldane and Moshinsky, 1939.)

With multiple alleles, $A_1, A_2, \ldots, A_k$ of frequencies, $q_1, q_2, \ldots, q_k$ where $\Sigma q=1$, the zygotic proportions of a panmictic population are given by

$$[\Sigma_i q_i A_i]^2=\Sigma_i q_i^2 A_i A_i+2\Sigma q_i q_j A_i A_j \quad (i<j),$$

and those of a population with inbreeding coefficient F are (*3*)

$$(1-F)\,[\Sigma_i q_i A_i]^2+F\Sigma_i q_i A_i A_i$$
$$=\Sigma_i\,[(1-F)q_i^2+Fq_i]\,A_iA_i+2(1-F)\Sigma q_iq_jA_iA_j(i<j).$$

If we use x_{ii} to denote the proportion of homozygotes A_iA_i in the population, then the equations specifying the above two populations are, respectively,

$$\Sigma_i \frac{x_{ii}}{q_i}=1 \tag{3}$$

$$\Sigma_i \frac{x_{ii}}{q_i}=1+F(k-1). \tag{4}$$

Their biological meaning is obvious. Note that q_i is equal to x_{ii} plus half the proportion of all heterozygotes carrying A_i. Letting $2x_{ij}$ be the proportion of A_iA_j, then $q_i=\Sigma_j x_{ij}$ (all j including $j=i$).

With k alleles, there are $K=k(k+1)/2$ genotypes. Such a population may be represented, using homogeneous coordinates as before, by a point P inside a regular simplex of $(K-1)$-dimensional space, letting

the perpendiculars from P to the K-bounding flats represent the zygotic proportions x_{ii}, $2x_{ij}$, etc., whose sum is unity. Eq. (3) or (4) defines the surface within the simplex on which all equilibrium population points lie.

Eq. (4) also furnishes us a ready method of estimating F from random samples. Let a_{ii} and $2a_{ij}$ be the observed numbers of A_iA_i and A_iA_j, $n_i = \sum_j a_{ij}$ (all j) and $N = \sum_i n_i$, the total number of individuals in the sample. Our sample estimate of F is then

$$f = \frac{1}{k-1}\left\{\sum_i \frac{a_{ii}}{n_i} - 1\right\}.$$

When $k = 2$, this estimate reduces to

$$f = \frac{a_{11}}{a_{11}+a_{12}} + \frac{a_{22}}{a_{12}+a_{22}} - 1,$$

which is identical with

$$f = \frac{a_{11}a_{22} - a_{12}^2}{(a_{11}+a_{12})(a_{12}+a_{22})},$$

as given by Haldane (*4*) and Li (*5*). Other methods of estimating F will be discussed elsewhere.

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The Reaction of Diazonium Salts with Alcohols

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The most remarkable thing about this "well-known" reaction is that it continues to be completely misunderstood in a great many quarters. Griess (*1*) in 1864 reported that benzene diazonium sulfate or nitrate reacts with ethanol to give benzene and acetaldehyde:

$$\text{Aryl—}N_2^+\,X^- + CH_3CH_2OH \rightarrow \text{Aryl—H} + CH_3CHO + N_2 + HX.$$

This came to be regarded as a general reaction despite the fact that numerous examples of an alternative process, replacement of the $—N_2^+$ by $—OCH_2CH_3$, were soon found:

$$\text{Aryl—}N_2^+X^- + CH_3CH_2OH \rightarrow \text{Aryl—}OCH_2CH_3 + N_2 + HX.$$

In 1887, it was shown by Remsen and Orndorff (*2*) that Griess had been in error even in the case of benzene diazonium sulfate and nitrate. These react with ethanol to give phenetole contaminated with a little benzene.

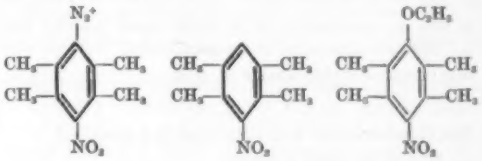
[1] Fellow of the John Simon Guggenheim Memorial Foundation and the United States Educational Commission in the United Kingdom, 1952–53.

In 1901, Hantzsch and Jochem (*3*) made a very careful study of the action of absolute ethyl alcohol on benzene diazonium chloride and benzene diazonium sulfate. Confirming Remsen and Orndorff, they found that phenetole is the main product, along with a very small quantity of benzene; e.g.:

$$C_6H_5—N_2^+\,Cl^- + CH_3CH_2OH \rightarrow \underset{(61\%)}{C_6H_5OCH_2CH_3} + \underset{(5\%)}{C_6H_6}$$

When they treated benzene diazonium salts with methyl alcohol the methyl ether (anisole) was formed in 70% yield; there was no evidence of benzene formation. Thus, with *either* ethanol or methanol, benzene diazonium salts give ethers as the major product.

Despite the numerous demonstrations of the unreliability of ethanol as a reagent for replacing the diazonium group by hydrogen, its use persisted. Cain (*4*), in 1909, reporting on the reaction of I with ethanol, was so confident that the product was nitrodurene, II, that he did not have it analyzed. Not until 1952 was it recognized that Cain's "nitrodurene" was, in fact, the ether, III (*5, 6*).



I II III

(Special interest attaches to this case because nitrodurene was employed in an early test of the concept of steric inhibition of resonance; the sample used had been prepared according to Cain and was actually the ether, III.)

In recent years the view that treatment of diazonium salts with ethyl alcohol results in replacement by hydrogen has been given renewed importance by totally incorrect statements concerning the course of the reaction of benzene diazonium chloride with ethyl alcohol. Incredible as it may seem, the paper by Hantzsch and Jochem (*3*) is cited as the authority for these statements. Thus, a review (1937) reads:

> The reactions of benzene diazonium chloride with methyl and ethyl alcohols are to an appreciable extent qualitatively different, as shown by Hantzsch and Jochem:
>
> $$C_6H_5N_2Cl + CH_3OH \rightarrow C_6H_5OCH_3 + N_2 + HCl$$
> $$C_6H_5N_2Cl + CH_3CH_2OH \rightarrow C_6H_6 + CH_3CHO + N_2 + HCl.$$[2]

Numerous statements made in subsequent years are even less guarded and are exemplified by the following excerpt from a well-known monograph (1949):

> It had previously been shown by Hantzsch and Jochem that the reactions with methyl and ethyl alcohols take different paths.
>
> $$C_6H_5N_2Cl + CH_3OH \rightarrow C_6H_5OCH_3 + N_2 + HCl$$
> $$C_6H_5N_2Cl + CH_3CH_2OH \rightarrow C_6H_6 + CH_3CHO + N_2 + HCl.$$[2]

[2] It would be invidious to give the references to these two quotations since they are but examples of a generalized situation.

In 1944, a correct account of the reactions of diazonium salts with alcohols was published in *Organic Reactions* (*7*), but it has apparently been overlooked by the majority of those who have since discussed this reaction.

In conclusion, two points should be emphasized: (1) ethyl alcohol is not, in general, dependable for replacing diazonium groups by hydrogen (*7*); (2) reduction with hypophosphorous acid is a reliable way to replace diazonium groups by hydrogen (*7, 8*). A second general method for replacing diazonium groups by hydrogen has just been described by Roe and Graham (*9*).

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Biosynthesis of Estrone and β-Estradiol in the Perfused Ovary[1]

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Zaffaroni, Hechter, and Pincus (*1*) found that the adrenal gland converts C^{14}-labeled acetate into adrenal hormones when it is perfused with a solution of this salt. Brady (*2*) showed that testis slices are capable of synthesizing testosterone from C^{14}-acetate, and Savard, Dorfman, and Poutasse (*3*) demonstrated conversion of labeled acetate to testosterone and Δ^4-androstene-3,17-dione in the perfusion of human testis. It therefore seemed interesting to investigate whether the ovary may synthesize estrone or β-estradiol from the same starting material.

The experiment was carried out by perfusing sow ovaries with sodium acetate labeled with C^{14} in the carboxyl group. The technique, including radioactivity counts, and the apparatus were the same as described in an earlier investigation (*4*).

Two perfusions of long duration were carried out with ovaries obtained from one pregnant and one nonpregnant sow. The animals each weighed about 200 lb. Two thousand units of heparin were injected intravenously before beginning the operation to obtain the ovaries. The large and small intestines were removed, and the aorta was litigated just below the origin of the ovarian arteries. The ovaries were freed of all adnexa. The aorta was then cut just above the origin of the ovarian arteries, and the entire specimen mounted in the perfusion apparatus. (As to the apparatus and procedure, *cf.* [*4*].)

The first experiment was carried on for 44 hr. During this time 1000 RU of gonadotrophin and 0.1125 mc of acetate labeled in the carboxyl group were added at 20 min, 9 hr, and 25 hr after circulation in the perfusion apparatus started. At the 9- and 25-hr intervals the perfusing medium was changed. The organ was without circulation for 30 min prior to beginning the perfusion.

In the second experiment, which lasted 13 hr, one injection of 1200 RU of gonadotrophin and 0.225 mc of labeled acetate was made 7 min after circulation was reinstated; the interruption of the circulation lasted 21 min.

The perfusion liquid in both experiments was a mixture of pig's blood and White's solution as described before (*4*). In each experiment the approximate volume of perfusate charging the system was 500 ml.

The weight of the ovaries in the first experiment was 6.1 g, in the second, 3 g. In both instances the organ appeared to have been well circulated by the perfusion liquid. No gross response to the gonadotrophin was evident, but there was also no significant degeneration discernible.

Extraction of the perfused ovaries. Immediately after the perfusion was terminated the mixture of ovaries and perfusion liquid was converted into a mash in a Waring Blendor. One third of the total volume of chloroform was added and again blended for about 10 min. The homogenous mixture was centrifuged at about 2000 rpm in the cold room. Three easily separable layers were formed; the lowest was a clear chloroform solution. The middle layer could be easily separated and consisted mostly of protein. This was stirred with acetone, and the acetone solution was filtered from the insoluble residue, which was again treated with acetone. The combined acetone extracts were evaporated to dryness and extracted with pentane. This solution was added to the chloroform layer. The uppermost layer from the centrifugation was a water solution which was extracted with chloroform. This extract was also added to the main choloroform portion. The combined extracts were then taken to dryness. The fatlike residue was boiled with methanol, and after cooling the clear methanol solution was decanted from the solid residue. This operation was repeated three times. The methanol extracts were evaporated to dryness and divided into two equal portions.

a) Isolation of estrone. The first part of the methanol extract was dissolved in about 10 ml methanol, and 200 mg of pure estrone was added and dissolved by warming. In the cold the estrone crystallized out

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and was filtered. It was recrystallized from methanol, and then showed a mp of 264°–266° C (Stage) which was not changed by another crystallization from methanol. This fraction had a specific count of 5 cpm/mg.[3] All mother liquor material was dissolved in ether, and this solution was extracted with 5% alkali. The alkali extract was acidified and extracted with ether. The residue from the ether solution was distilled in high vacuum at a bath temperature of 120°–160° C, and the substance thus obtained was recrystallized twice from acetone. The melting points of the crystals were the same as above. The specific count for this fraction was 3 cpm/mg.

b) Isolation of β-estradiol. The second portion of the methanol extract was dissolved in about 10 ml methanol, and 200 mg of β-estradiol (mp 172°–174°) was added. The material which crystallized out on cooling was crystalline but impure and could not be purified by further crystallization. It was recombined with the mother liquor and this mixture dissolved in ether, which was extracted with 5% KOH. The alkaline extract was acidified and extracted with ether. The residue from this ether solution was distilled in high vacuum at 120° bath temperature, and the material obtained was recrystallized from acetone, the crystals washed with cold ether and then recrystallized from acetone-hexane. The mother liquor was decanted from the crystals and these again crystallized from aqueous acetone. The crystals thus obtained sintered at 173° and melted at 177°–181° C (Stage). A further recrystallization from methanol gave a mp of 176°–177° C. This fraction gave a specific count of 3 cpm/mg.

c) Isolation of cholesterol. All mother liquor material in the second experiment was combined and boiled for 5 hr with 15 ml of a 10% solution of KOH in 95% ethanol. This reaction mixture was extracted with pentane, which after evaporation gave a crystalline residue of yellow color. It was treated with digitonin in the usual fashion, and the cholesterol was isolated from the digitonin complex. The specific count was 434 . Dibromination and reconversion gave a pure cholesterol which had a specific count of 75, thus showing the presence of higher counting companions (HCC) in the crude cholesterol (*5*).

The experiments here reported show that isolated surviving sow ovaries when perfused with sodium acetate labeled in the carboxyl group produce labeled estrone, β-estradiol, and cholesterol. Westerfeld *et al.* (*6*) many years ago isolated β-estradiol in substance from ovaries, and MacCorquodale *et al.* have secured the simultaneous presence of estrone by unmistakable reactions (*7*). Beall also observed the presence of both estrogens together in horse testes (*8*).

Like the testis in the earlier investigation, the ovary produces C^{14}-cholesterol simultaneously with the hormones. The experiments as described do not allow any conclusion as to whether the hormones are derived from this cholesterol, or whether cholesterol and the hormones are produced from a common precursor.

[3] All counts in this investigation were made in a gas flow counter. For the preparation of the samples for counting compare (*4*).

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Structural and Energy Relationships in the Formation of Iron and Aluminum Oxides, Hydroxides, and Silicates[1]

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Iron and aluminum oxides, hydroxides, and silicates are of great importance in the mineral content and formation of soils and sediments. Their structural relationships, known from x-ray diffraction methods and bonding considerations, are shown herein to help explain their occurrence. Recently, Ervin (*1*) considered the diaspore-corundum and boehmite-Al_2O_3 systems, and he has shown that they are structurally related. Structural interrelationships with genesis can be shown for iron and aluminum silicates, as well as for their oxides and hydroxides. These considerations, together with energy changes, are summarized in Fig. 1. (Downward slope of arrows is indicative of ease of occurrence.)

In the aluminum system, dehydration of $Al(OH)_3$ (gibbsite) results in the formation of AlOOH (boehmite, reaction *f*, Fig. 1). Dehydration may be accomplished by increase of temperature or decrease of suspension pH. Milligan (*2*) has reported boehmite to

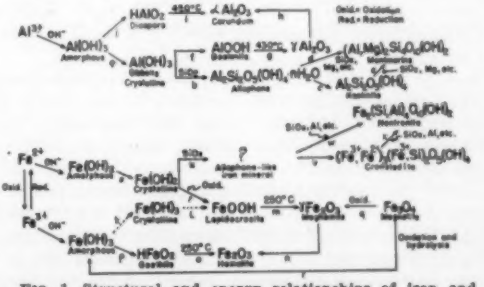

FIG. 1. Structural and energy relationships of iron and aluminum oxides, hydroxides, and silicates. (Downward slope of arrows indicative of ease of reaction occurrence.)

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be formed from solutions of pH below 6.5. In the alteration of gibbsite-boehmite colloid to kaolin, in the presence of silica solutions, 1 oxygen atom of a silica tetrahedron (4 oxygens coordinated by the 4-valent Si ion) is believed to replace a position left vacant in a gibbsite octahedron (6 oxygens coordinated by trivalent Al) on partial dehydration. The process continues by entrance of silica solution between the hydrogen-bonded crystal layers which form gibbsite crystals. Although the hexagonal network of silica tetrahedra would permit a complete replacement of the vacant oxygen positions to give a kaolin family crystal structure, this probably does not occur immediately, since the apical oxygens of silica may not at first be unidirectionally oriented. Incomplete bonding to both adjacent gibbsite crystal layers may at first give rise (reaction *b*) to an amorphous mineral, allophane, described by Ross and Kerr (*3*). Allophane is characterized by a high water content and is frequently associated with the kaolin family. Its high water content and the continuous removal of water as the temperature is raised from room temperature to 900° C may be due to "trapped" water within the interlayer made up of a silica-alumina network, in contrast to water lost from between the well-organized 1 : 1 layers of hydrated halloysite. Also, some of the interlayer surfaces of partially silicated $Al(OH)_3$ are greatly exposed by expansion and would lose water at low temperature. Infrared absorption spectra of allophane have shown that it is not a mixture of alumina and silica (*4*).

Allophane is visualized as forming kaolin on completion of unidirectional bonding through alternate wetting and drying in an acid medium (reaction *c*). The transition of kaolin to the montmorin (montmorillonite isomorphous series) structure (reaction *e*) is believed to be accomplished in the following way. Magnesium and iron can replace aluminum along the edges of the octahedral sheet of kaolin; in so doing, the larger size of the magnesium and iron atoms stretches the octahedra in which they are coordinated. Magnesium would further instabilize the hydroxyls by its divalence on substitution for a trivalent aluminum in dioctahedral silicates. Table 1 shows the decreased dehydration temperatures of the 2:1 layer silicates with different isomorphous substitution in the dioctahedral layers.

The data show that the 2 : 1 layer silicates decrease in thermal stability with increasing isomorphous substitution. They further show that magnesium decreases the dioctahedral stability nearly as much as iron, even though trioctahedral magnesium layer silicates (*5*) have a high dehydration temperature. In the kaolin minerals, there are four hydroxyls instead of the two present in 2 : 1 layer silicates. When magnesium substitutes for aluminum in kaolin, the hydroxyls become less tightly bound; and in the presence of silica in solution, the montmorin series of minerals appears, from soil mineral colloid studies here, to result (reactions *d* and *e*). The occurrence of magnesium and silica in abundance in soils is usually limited to situations in which there is little leaching, and reactions *d* and *e* are thus the reverse of normal weathering (*8*). Such reactions have occurred in the dark magnesium soils of Hawaii, where magnesium and silica, together with kaolin sediments, have been carried into the valleys from adjacent mountains and formed montmorin. In a latosol in the Dominican Republic, antigorite (Mg-kaolin) has been found to have reverted in part to montmorin.

TABLE 1

DEHYDRATION TEMPERATURES OF DIOCTAHEDRAL 2 : 1 LAYER SILICATES WITH DIFFERENT ISOMORPHOUS SUBSTITUTIONS

Octahedral ions				Sum of cations	Dehydration temperature °C.*	Literature sources
Al^{3+}	Fe^{3+}	Fe^{2+}	Mg^{2+}			
2.00	—	—	—	2.00	650	(*5*)
1.61	—	—	0.40	2.01	580	(*6*)
1.48	0.14	—	.39	2.01	560	(*6*)
0.77	1.10	0.02	.19	2.08	490	(*7*)
0.11	1.91	0.02	0.04	2.08	440	(*7*)

* The dehydration temperatures recorded are the approximate midpoint in the integral thermal curves.

Although boehmite (AlOOH) is formed by the dehydration of gibbsite (reaction *f*), its iron analog lepidocrocite (FeOOH) is formed from the oxidation of ferrous compounds (reaction *t*). Crystalline $Fe(OH)_3$, the analog of gibbsite (and thus the natural precursor of FeOOH, by reaction *L*), has not yet been reported. The gibbsitelike layer structure of $Fe(OH)_2$ reverts to lepidocrocite on oxidation and dehydration, a transformation identical to the gibbsite-boehmite transition except for the oxidation.

Possible reasons for the instability of crystalline $Fe(OH)_3$ in comparison with crystalline $Al(OH)_3$ and $Cr(OH)_3$ may be attributed to the influence of *d* electrons.[2] If the concept of resonance is applied, instability of $Fe(OH)_3$ may be attributed to the absence of ionic-covalent resonance. One of the rules regarding resonance states that resonance can occur only among structures with the same number of unpaired electrons (*9*). Both aluminum and chromium are known to form crystalline hydroxides, and their electronic structures are such as to permit resonance between the ionic and covalent forms; the resonance energy helps to stabilize the structure. Trivalent iron has five unpaired 3*d* electrons in the ionic bond (e.g., FeF_6^{---}) and one unpaired 3*d* electron in the covalent bond—e.g., $Fe(CN)_6^{---}$—there can be no resonance between the two bond types. If the concept of polarization is applied, instability of $Fe(OH)_3$ is accounted for by the increase of polarizing power of cations with increasing charge and increasing number of *d* electrons. The instability of $Zn(OH)_2$ with respect to the

[2] The *d* electron is an electron of a designated orbital energy range within a given electronic shell of an atom; in the case of iron atoms considered here, the 3*d* electrons occur in the *M*-shell, the latter being indicated by number 3.

$Mg(OH)_2$-type structure has been explained on the basis of the high polarizing power of divalent zinc which has ten 3*d* electrons (*10*). Trivalent aluminum exhibits the effect of polarization by directed hydroxyls in $Al(OH)_3$ (*11*). Chromium with three 3*d* electrons is known to form $Cr(OH)_3$, but $Cr(OH)_3$ is unstable even at room temperatures (*2*). It would seem reasonable to assume that $Fe(OH)_3$ would be less stable than $Cr(OH)_3$, since ferric iron has five 3*d* electrons.

The change of $Fe(OH)_3$ to the more stable partially dehydrated form (goethite, reaction *p*) occurs before crystalline $Fe(OH)_3$ forms (reaction *k*). That goethite may be more stable than lepidocrocite is shown by the dehydration temperatures of their respective Al analogs diaspore > boehmite (Fig. 1). The identical temperature recorded for the goethite and lepidocrocite dehydrations (*12*) may be due to smaller particle size of goethite or other difficulties in the method of measurement.

In the presence of silica, a ferrous mineral similar to allophane would be expected from $Fe(OH)_2$ (reaction *u*). Thus far it has not been identified positively, although exchange capacities of amorphous ferruginous soil colloids are at present being postulated at several laboratories. However, there are several crystalline iron 1 : 1 layer silicate minerals that are similar to kaolinite; the minerals cronstedite and greenalite are examples (reaction *v*). The trioctahedral nature of the iron in the mineral cronstedite suggests that cronstedite is formed from ferrous hydroxide. Hendricks (*13*) considers the octahedral iron of cronstedite as being due to the replacement of silicon by large ferric iron in the tetrahedral position, which allows the octahedral layer to be "opened" up. In view of the transformation just considered, it would seem that the ferrous iron in the octahedral position opened up the structure, and this in turn allowed the ferric iron to enter into the tetrahedral position. This would be similar to the kaolin-montmorin transition, except that it would be expected to occur with a deficiency of silica and excess of ferrous iron in the environment. In greenalite there is a mixture of ferrous and ferric ions octahedrally coordinated, and silica presumably in tetrahedral coordination. It is formed in iron-rich environments, from iron silicates in iron ore deposits (*14*).

When great excess of silica is present, the ferric member of the montmorin series can be formed as evidenced by nontronite (reactions *w* and *x*), which typically occurs embedded in a silica matrix.

Franzen and Eyk van Voorthuysen (*15*) have accomplished the synthesis of nickel layer silicates, which further emphasizes the importance of the hydroxyl layer structure such as in $Ni(OH)_2$, to formation of the corresponding layer silicates. Nickel and ferrous ions are similar in their electronic configuration, but both have lower polarizing power than the ferric ion.

Although in the tropics there is an abundance of iron and aluminum oxides and hydroxides, layer silicates with iron are rare. This is due to the rapid oxidation of ferrous iron to ferric, which gives rise to goethite and hematite, owing to the instability of $Fe(OH)_3$ as already discussed. Decomposition of magnetite is generally accompanied by hydrolysis and oxidation. Without hydrolysis, maghemite (γ-Fe_2O_3) is formed. Because silica and the bases are rapidly leached in well-drained soils, the montmorin series in which iron might be substituted is disfavored and the formation of aluminum members of the kaolin family is favored.

In the temperate regions, where decomposition of primary minerals and leaching of silica and bases are relatively slower and less complete than in the tropical weathering referred to, the 2 : 1 layer silicate minerals bearing some iron ions are common, but give way (*8*) to kaolin as weathering progresses.

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Substrate Competition between Procaine and Succinylcholine Diiodide for Plasma Cholinesterase

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It was shown by Kalow (*1*) that the enzyme responsible for the hydrolysis of procaine in plasma is identical with cholinesterase (nonspecific cholinesterase, pseudo-cholinesterase). It was also demonstrated by Glick (*2*) and more recently by others (*3–7*) that plasma cholinesterase is capable of hydrolyzing succinylcholine, a recently introduced muscle relaxant. In the course of clinical studies with succinylcholine diiodide (*8*), it was observed that, when 100 mg procaine was administered intravenously to patients receiving succinylcholine, the respiratory depth decreased markedly for several minutes, and in

TABLE 1

THE EFFECT OF THE INTRAVENOUS INJECTION OF PROCAINE ON RESPIRATION IN PATIENTS RECEIVING SUCCINYLCHOLINE DIIODIDE IN CONTINUOUS INTRAVENOUS DRIP

Patient	Procaine (mg)	Onset of respiratory depression* (sec)	Duration of respiratory depression (min)	Remarks
B. M.	30	60	12	Apnea 8 min
A. G.	100	30	2	Moderate effect
H. C.	100	55	6	
J. W.	100	30	2	
S. E.	100	—	—	No appreciable respiratory depression
M. K.	100	70	6	
M. B.	100	45	5	Respiratory arrest; succinylcholine discontinued at 2½ min
J. F.	100	30	6	
E. P.	100	60	4	Moderate effect
G. M.	50	60	2	
J. J.	100	60	6	

* After the injection of procaine.

a few instances respiratory arrest developed (Table 1). These patients were anesthetized with a combination of nitrous oxide-oxygen and thiopental sodium, and received succinylcholine by continuous intravenous drip at a rate of 2–8 mg/min.

It was conceivable that since both procaine and succinylcholine are hydrolyzed by the same enzyme, the additive effect of the simultaneous administration of procaine and succinylcholine diiodide on respiratory depth might be due to substrate competition between the two agents for the plasma cholinesterase. Under clinical conditions, the measurement of this effect could not be carried out easily; therefore experiments were designed for the quantitative determination of this substrate competition by *in vitro* hydrolysis studies and to observe the action of procaine on the succinylcholine-induced neuromuscular blockade in animal experiments.

To four 1.6-ml aliquots of heparinized human plasma, procaine was added in sufficient quantities to obtain procaine concentrations of 50, 100, 200, and 400 μg/ml, respectively. To another four plasma samples, in addition to the same procaine concentrations, 100 μg/ml succinylcholine diiodide was added. In yet another four plasma samples, the procaine concentration was kept constant, and the succinylcholine diiodide concentrations were made to be 50, 100, 200, and 400 μg/ml, respectively. All plasma samples were incubated at 37° C for 10 min. The procaine and *p*-aminobenzoic acid concentrations at the end of the hydrolysis were determined in duplicate by Ting's method (*9*). The findings are summarized in Table 2.

TABLE 2

THE EFFECT OF SUCCINYLCHOLINE ON THE ENZYMATIC HYDROLYSIS OF PROCAINE IN PLASMA

Procaine concentration (μg/ml)	Succinylcholine concentration (μg/ml)	Procaine hydrolyzed (μg/ml)	
		Plasma 1	Plasma 2
50	0	48	48
100	0	50	44
200	0	54	53
400	0	56	47
50	100	28	26
100	100	38	32
200	100	47	38
400	100	57	46
100	50	42	37
100	100	35	31
100	200	31	25
100	400	24	19

It can be seen from Table 2 that, in agreement with previous findings (*10*), increasing the procaine concentration from 50 to 400 μg/ml had very little effect on the quantity of procaine hydrolyzed (zero order reaction). In contrast to this, when 100 μg/ml succinylcholine diiodide was added to the systems before incubation, the quantities of procaine hydrolyzed increased with increasing procaine concentrations. Similarly, when the procaine concentration was kept constant at 100 μg/ml and the succinylcholine diiodide concentration was increased, the quantity of procaine hydrolyzed decreased with increasing succinylcholine diiodide concentrations.

The inhibitory effect of procaine-HCl and succinylcholine dichloride on the enzymatic hydrolysis of one another was further investigated by Warburg's micromanometric technique and Ting's method for the determination of procaine-HCl. The findings of these experiments (to be presented in detail elsewhere) are summarized in Table 3. The figures of Table 3 indicate that procaine-HCl inhibits the enzymatic hydrolysis of succinylcholine dichloride and, in agreement with the experiment summarized in Table 2, succinylcholine inhibits the enzymatic hydrolysis of procaine-HCl. It is also evident that the inhibitory effect of procaine-HCl on the enzymatic hydrolysis of succinylcholine dichloride depends on the relative concentration of the two substrates. The greater the procaine-HCl/succinylcholine dichloride ratio, the greater the inhibitory effect. The figures of Table 3 also show

TABLE 3

THE EFFECT OF PROCAINE AND SUCCINYLCHOLINE ON THE ENZYMATIC HYDROLYSIS OF EACH OTHER*

Substrate concentration/ml plasma	Succinylcholine dichloride hydrolyzed (μg/ml)		Procaine HCl hydrolyzed (μg/ml)	
	Plasma 1	Plasma 2	Plasma 1	Plasma 2
Succinylcholine dichloride 5000 μg	3490	3120	—	—
Procaine HCl† > 100 μg	—	—	1650	1650
Succinylcholine dichloride 5000 μg	1375	1920	219	297
Procaine HCl 500 μg				
Succinylcholine dichloride 5000 μg	484	790	562	734
Procaine HCl 2500 μg				

* Hydrolysis carried out at 37° C in 0.025 *M* bicarbonate-5% CO_2 buffer system in Warburg vessels for 120 min.
† Calculated from the data of Table 2.

that the inhibitory effect of procaine-HCl on the enzymatic hydrolysis of succinylcholine dichloride is greater than that of succinylcholine dichloride on the enzymatic hydrolysis of procaine-HCl. This indicates that although the hydrolysis rate of succinylcholine dichloride is greater than that of procaine-HCl, the affinity of procaine-HCl to the enzyme is considerably greater than that of the succinylcholine dichloride. This finding is in agreement with the observation of Kalow (*11*) who found that the affinity of the plasma cholinesterase for procaine is about 220 times greater than that of acetylcholine.

The additive effects of succinylcholine and procaine could also be demonstrated with mammalian sciatic-gastrocnemius preparations. Dogs and cats were anesthetized by the intraperitoneal injection of sodium pentobarbital in a dosage of about 35 mg/kg. The isometric twitches of the gastrocnemius in response to single submaximal stimuli applied to the sciatic nerve were recorded, and arterial blood pressure was recorded from a carotid cannula. In the experiment presented in Fig. 1, the gastrocnemius twitch was depressed to about 10% of the control value by the continuous intravenous administration of 0.02 mg/kg/min of succinylcholine diiodide. At the point indicated by the arrow, 2.0 mg/kg of procaine was administered intravenously. Within a minute the gastrocnemius twitch was completely abolished. On discontinuing the infusion of succinylcholine, the gastrocnemius twitch began to return. Infusion of succinylcholine diiodide at the rate of 0.04 mg/kg/min again rapidly abolished the twitch. Subsequently, 90% depression of the twitch response could be maintained by the continuous intravenous infusion of only 0.01 mg/kg/min.

TABLE 4

THE HYDROLYSIS RATE OF PROCAINE* IN PLASMA AT 37° C

Species	Percentage hydrolyzed in 20 min	Percentage hydrolyzed in 180 min
Man	100	—
Cat	7	74
Dog	3	16

* The procaine concentration was 100 μg/ml.

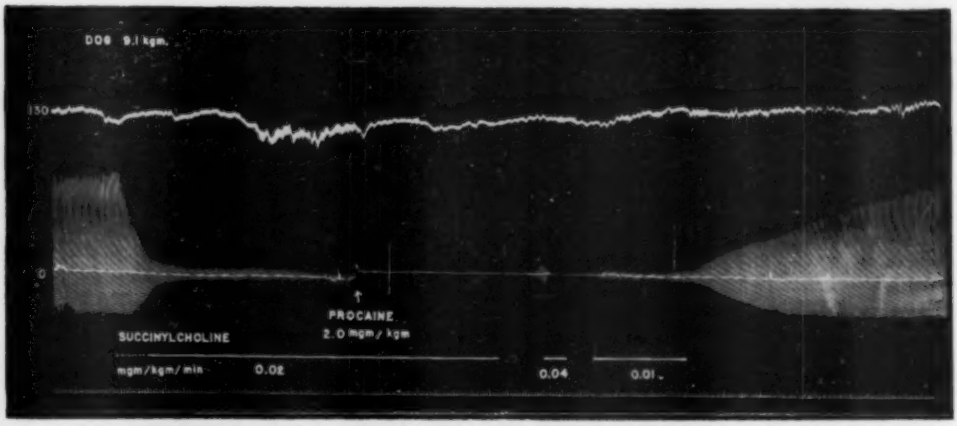

FIG. 1. The effect of procaine on neuromuscular block produced by succinylcholine in dog.

In view of the fact that procaine is hydrolyzed very rapidly both *in vivo* (*12*) and *in vitro* (*10*) by human plasma, the long-lasting additive effect of procaine on succinylcholine activity in dogs (and also in cats) was surprising. However, *in vitro* hydrolysis experiments with dog and cat plasma (Table 4) indicated that compared to man, the plasma cholinesterase activity in these animals was very low.

This circumstance might account for the finding

that the mg/kg dose of succinylcholine diiodide on single intravenous administration was much lower (0.05 mg) in dog and cat (*4, 13*) than in man (0.5 mg) (*8*), and that the inhibition of neuromuscular transmission following a single dose also lasted longer in dog and cat than in man. Similarly, the mg/kg/min dose of succinylcholine diiodide (0.04–0.12) was also considerably greater in man (*8*) than in dog and cat.

According to Harvey, procaine prevents acetylcholine from acting, by interfering with the acetylcholine receptor mechanism (*14*). It has also been shown that procaine inhibits acetylcholine release at the neuromuscular junction (*15*). According to the present accepted theory of the mechanism of action of the different types of muscle relaxants (*16*), the suppression of acetylcholine release or prevention of its action should increase the effectiveness of the antidepolarizing muscle relaxants (curare, Flaxedil, etc.), but decrease the effect of the depolarizing agents (decamethonium). Inasmuch as succinylcholine has been classified as one of the depolarizing relaxants (*17, 18*), procaine would be expected to decrease its effectiveness. In contrast to this, it was found (Fig. 1) that in the dosage and manner used (2 mg/kg in dogs) procaine increased the intensity of neuromuscular blockade produced by succinylcholine. It is conceivable that under the experimental conditions reported, the effect of procaine on plasma cholinesterase activity was dominant over its antidepolarizing action (*14, 15*). Under other experimental conditions, it was possible to demonstrate that procaine is also capable of antagonizing the succinylcholine-induced neuromuscular blockade (*19*).

It was observed in patients and demonstrated in animal experiments that the intravenous injection of procaine during succinylcholine administration increased the inhibitory effect of succinylcholine on neuromuscular transmission. This resulted in an increased respiratory depression in patients, and a decreased response of the sciatic-gastrocnemius preparation to repeated single electrical stimuli in animals. *In vitro* hydrolysis studies demonstrated that substrate competition exists between procaine and succinylcholine for the plasma cholinesterase. The practical importance of this observation lies in the fact that procaine and succinylcholine might be employed simultaneously in anesthetized patients, and therefore the anesthesiologist has to be aware of possible additive effects of these two agents.

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Effects of Ferric Chloride and Bile on Plasma Cholesterol and Atherosclerosis in the Cholesterol-fed Bird[1]

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Because of its possible importance in atherogenesis, the level of plasma cholesterol has received considerable attention in recent years. Severe restriction of foodstuffs rich in lipides has been the most practical method so far proposed for lowering the concentration of circulating cholesterol. In this laboratory, however, we have been interested in procedures other than those involving dietary restrictions for the control of plasma cholesterol. We have recently shown that absorption of cholesterol from the intestinal tract stops completely in the absence of bile (*1*), and this observation suggested to us the feeding of ferric chloride, which is known to precipitate bile salts *in vitro*. It is shown here that the rise in plasma cholesterol, as well as the associated atheromata resulting from cholesterol feeding, can to a large degree be prevented by the feeding of ferric chloride.

Experiment I. Four-month-old White Leghorn cockerels, obtained through the courtesy of the Depart-

TABLE 1

COMPOSITION OF DIETS*

Expt.	Group	Diet	Wesson oil	Cholesterol	Ferric chloride	Bile concentrate
I	1	A	5	None	None	None
	2	B	5	1	"	"
	3	C	5	1	3	"
II	4	D	5	None	None	10
	5	E	5	1	"	10
	6	F	5	1	3	10
III	7	E as above				
	8	F " "				

* Percentage of Purina broiler chow (starter ration), with added constituents.

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[2] The technical assistance of Jacob V. Sherokoff and Donna M. Folliard is gratefully acknowledged.

ment of Poultry Husbandry of this university, were used. They were fed Purina broiler chow (starter ration) for a period of 4 weeks, during which time 2 samples of blood were taken for determination of plasma cholesterol. They were then divided in three groups of 3 birds each and treated as follows: Group 1 was fed Diet A; Group 2 was fed Diet B; and Group 3 was fed Diet C (Table 1). The birds were kept on the diets for about 5 months. Food consumption for each bird was measured daily (Table 2).

TABLE 2

AVERAGE FOOD CONSUMPTION
(Grams consumed per bird per day)

Expt.	Group	Months					
		1	2	3	4	5	6
I	1	114	98	87	53	57	....
	2	95	89	71	54	60	....
	3	100	89	83	50	....	....
II	4	94	99	84	65	65	71
	5	106	105	84	73	63	67
	6	85	79	78	59	59	48
III	7	89	67	62	70	....	....
	8	96	76	69	71	....	....

The total cholesterol of the plasma was measured on five occasions; the average values for the birds of each group are shown in Fig. 1. Plasma cholesterol

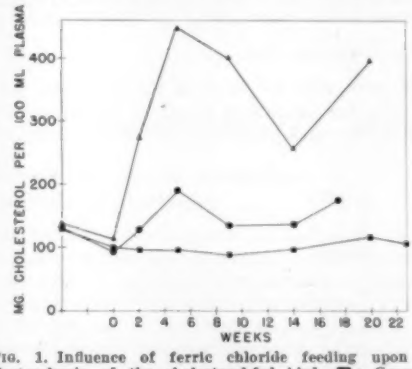

FIG. 1. Influence of ferric chloride feeding upon the cholesterolemia of the cholesterol-fed bird. ■: Group 1, regular diet; ▲: Group 2, regular diet + 1% cholesterol; ●: Group 3, regular diet + 1% cholesterol + 3% ferric chloride.

was determined by a modification of the method of Sackett (*2*).

The feeding of cholesterol plus fat resulted, as was to be expected, in a pronounced increase in the cholesterol concentration of plasma (Group 2). The highest value was observed about 1 month after the feeding of the diet was started, and at this time the average cholesterol value was 450 mg %.

It is clear from Fig. 1 that the addition of iron to the cholesterol-fat diet inhibited the rise in plasma cholesterol. The values for the iron-cholesterol–fed birds (Group 3) were higher than those found in the

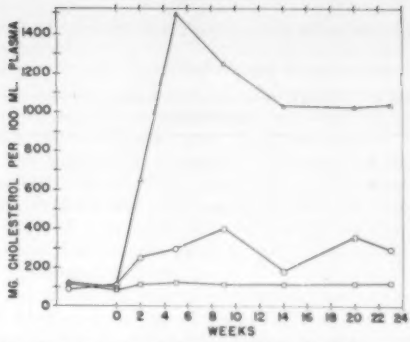

FIG. 2. Influence of ferric chloride feeding upon the cholesterolemia of the cholesterol-bile–fed bird. □: Group 4, regular diet + 10% bile concentrate; △: Group 5, regular diet + 1% cholesterol + 10% bile concentrate; ○: Group 6, regular diet + 1% cholesterol + 10% bile + 3% ferric chloride.

controls (Group 1), but in no case did the plasma cholesterol concentrations in the birds of Group 3 approach those observed in the birds fed cholesterol alone (Group 2).

At the termination of the study (17–23 weeks) autopsies were performed on all animals. The heart and aorta of each bird were dissected out and carefully examined for gross atheromata. Severity of the thoracic and abdominal aortic lesions was graded as follows:

0: No gross changes
0.5: Extensive coalescing intimal discoloration, lacking a grossly elevated intimal surface
1: Definite plaques less than 3 mm², white to cream-colored, with raised intimal surface
2: Definite plaques greater than 3 mm², cream to light yellow in color
3: Numerous plaques greater than 3 mm², yellow in color
4: Severe gross atheromatosis (lesions yellow in color, raised and calcified on gross examination)

Examination of the aortas at the end of the experiment indicated that there were fewer lesions in the birds that received ferric chloride plus cholesterol than in those fed cholesterol alone. The prolonged feeding of the large amounts of ferric chloride was not, however, without toxic action. Cataract formation, decreased food intake, and weight loss were observed about the 14th week of the experiment. For this reason we cannot conclude from this experiment that the ferric chloride per se was responsible for the lesser degree of atherogenesis in the birds of Group 3. But, as judged by the intake of food, gain in weight, and the general well-being of the bird, no toxic effects were encountered until the period of about 3½ months had elapsed. Table 2 shows that during these first 3½ months the iron-fed birds (Group 3) actually ingested slightly more food, and hence more cholesterol, than did the birds of Group 2. Despite this, however, plasma cholesterol in the birds of Group 3 remained lower than in those of Group 2.

Experiment II. In view of the role of bile in choles-

TABLE 3

EFFECT OF FERRIC CHLORIDE UPON DEGREE OF ATHEROSCLEROSIS IN CHOLESTEROL-FED BIRDS AND BIRDS FED CHOLESTEROL PLUS BILE

Expt.	Group	Diet			Bird	Aorta		Degree of Atherosclerosis
		Cholesterol	Bile	$FeCl_3$		Thoracic	Abdominal	
I	1	None	None	None	1	0.5	0	0.17
					2	0	0	
					3	0.5	0	
	2	+	"	"	4	0	0	0.92
					5	0	2	
					6	0.5	3	
	3	+	"	+	7	0	0	0.33*
					8	0	2	
					9	0	0	
II	4	None	+	None	10	0	2	0.33
					11	0	0	
					12	0	0	
	5	+	+	"	13	2	4	2.50
					14	2	3	
					15	1	3	
	6	+	+	+	16	0	0	0.50
					17	2	0	
III	7	+	+	None	18	3	2	2.67
					19	3	2	
					20	3	3	
					21	†	†	
	8	+	+	+	22	0	2	0.62
					23	0	3	
					24	0	0	
					25	0	0	

* This value may be low since the birds of group 3 were sacrificed earlier than those of the other groups of this experiment.

† Bird died in cage and severe postmortem changes made gross grading impossible.

terol absorption we undertook a study of the effect of the simultaneous administration of cholesterol and bile upon plasma cholesterol levels and atherogenesis. Three groups of birds (3 in Groups 4 and 5, 2 in Group 6) were fed as follows:

Group 4 was fed Diet D (Table 1). The bile as obtained from the abbatoir was concentrated to approximately 1/7 of its volume by heating overnight at 100° C and passing a stream of air over its surface to facilitate evaporation. Group 5 was fed Diet E. Group 6 was fed Diet F.

The birds used in Expts. I and II were from a single hatch, and both experiments were run concurrently. The feeding in Expt. II was continued for about 6 months.

The food intake of the 8 birds used in Expt. II is given in Table 2. Their plasma cholesterol values are shown in Fig. 2, and the degree of atheromatosis in Table 3.

The addition of bile to the cholesterol diet resulted in an extraordinary rise in plasma cholesterol (*cf.* Group 2 in Fig. 1 with Group 5 in Fig. 2). At the end of 2 weeks these birds showed cholesterol levels ranging from 420 to 850 mg %, and by the time 5 weeks had elapsed the values were 1022–2017 mg %. The average values throughout the remainder of the 6-month period did not drop below 1000 mg %.

Good evidence that the degree of atheromatosis keeps pace with the level of plasma cholesterol is shown by the comparison of plaque formation in the birds of Group 2 (Expt. I) with those of Group 5

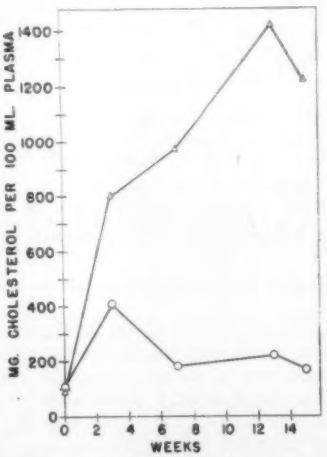

FIG. 3. Influence of ferric chloride feeding upon the cholesterolemia of the cholesterol-bile–fed bird. △: Group 7, regular diet + 1% cholesterol + 10% bile concentrate; ○: Group 8, regular diet + 1% cholesterol + 3% ferric chloride.

(Expt. II). Atheromatosis was 3 times as extensive in the birds of Group 5 as in those of Group 2.

The dramatic action of iron feeding in the prevention of the rise in plasma cholesterol is clearly shown in Fig. 2. The feeding of iron even in the presence of bile (Group 6) held plaque formation to a degree approximately 1/5 that observed in birds of Group 5. No toxic manifestations (cataracts or weight loss) were noted in the birds fed the ferric chloride-containing diet.

Experiment III. Two groups of birds (4/group) were studied in this experiment (Table 1). Group 7 was fed Diet E. Group 8 was fed Diet F.

The birds were 5 months old at the start of the feeding, and the experimental period was shortened to 4 months. During this period no untoward manifestations were noted in the birds fed the iron-bile-cholesterol diet.

The results of the experiment, shown in Fig. 3 and Table 3, are essentially the same as those of the second experiment. The degree of atheromatosis in the birds fed bile and cholesterol was approximately 4 times as great as that observed in the birds fed bile, cholesterol, and iron.

The interesting finding is that the feeding of ox bile along with cholesterol results in a greater degree of atherosclerosis, as well as a higher cholesterolemia, than does the feeding of cholesterol alone. The hypercholesterolemic effect of bile, which has been noted previously (*3, 4*), is probably the result of augmented cholesterol absorption. This view is supported by the observation that birds fed Purina chow supplemented with Wesson oil and bile but no cholesterol showed no greater cholesterolemia nor atheromatosis than control birds fed the Purina chow plus Wesson oil.

The enteral administration of ferric chloride reduced the extent of the rise of plasma cholesterol not only in birds fed cholesterol but also in those fed cholesterol plus bile. It is likely, although not yet proved, that the iron acted by precipitating bile salts in the intestinal tract.

The action of bile in facilitating the appearance of atheromata in the cholesterol-fed bird, as well as an earlier finding that bile controls the rate of cholesterol absorption by the intestine in the rat (*1*), raises an interesting point—namely, the part played by intestinal bile in the development of arteriosclerosis in man. Our findings suggest that the binding of bile salts in the intestinal tract, thereby suppressing cholesterol absorption, may offer a means of controlling the development of arteriosclerosis.

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Comments and Communications

Photoperiodicity in Animals: The Role of Darkness

Recent results with quail (*1*) have been claimed as apparently "the first clarification of the importance of the dark period in the photoperiodic responses of any higher animal" (as opposed to results with plants, aphids, and snails). In a neat experiment, 5 groups of birds were exposed to artificial lighting daily: either as 17 hr (followed by 7 hr darkness) or as 9 hr plus 1 hr (the two periods separated by a 0-, 1½-, 3½-, or 7-hr dark period, and followed by another dark period to complete the 24-hr cycle).

The results are summarized by pointing out that stimulation (gonad and oviduct size) is roughly "inversely proportional to the length of the longest dark interval. . . . It is evident that the dark period is an inhibitory factor." The growth effects obtained with 17 hr light (and one 7-hr dark period) seem to have been about the same as with 10 hr total light (with two 7-hr dark periods daily).

These results might have been expressed in another way—that stimulation was roughly proportional to the length of day (above a threshold level); and that the "day" did not have to be continuous but could be broken by a dark interval. It is perhaps a mistake to think of darkness—which is merely the absence of light—as playing an active role.

Hart's demonstration (*2*) that ferrets would become oestrous if the dark period was broken was open to criticism (*1*). But experiments (*3*) at the Worcester Foundation, based on Hart's results, showed that only 7 hr illumination daily, if divided over a 12-hr period, will stimulate: so indeed (*4*) will 4 hr divided over 14 hr.

There seem to be differences between photoperiodic mechanisms of birds and mammals; but in both there is evidence that the length of the dark period affects the response to light, and not in an inhibitory fashion. In the weaverbird (*5*) an optimum length of day (and hence of night) has been postulated. In the ferret interpretation of experiments is complicated by what has been termed an "inherent rhythm" (*6*).

This rhythm may be due, or partly due, to the dissipation in darkness of inhibitory aftereffects of long days. Analogy with results on mink (*3, 7*) suggests this: stimulatory effects of light can be stored for long periods (*4*).

Hart (*2*) found a more rapid response to 16 hr

than to 24 hr of light daily; unfortunately, his lighting intensity fluctuated. However, with constant intensity (*4*) response was more rapid with 14 hr than 24 hr of illumination. Indeed, in the latter experiment the delay in response with 24 hr of light was such that onset of oestrus might be attributed to an "inherent rhythm" (supposing it "independent of light"), rather than to the long day length.

Part of another experiment (*8*) also demonstrates that darkness enhances the response to light. Nine ferrets (after a year on rather complex, controlled, artificial light schedules) were on Aug. 18 put in 3 groups—on 15 hr light, on 18 hr light, and on 6 hr divided light (4 hr + 2 hr) spread over 15 hr, each day. (They were kept thus for a year; but oestrus developed much sooner than that.) One in each group was in fact oestrous when the phase which is reported here started; dates when the others became oestrous are shown in Table 1. On previous phases of the experiment there was little individual variation.

TABLE 1

Animal	15 hr	18 hr	Broken 15 hr
(i)	Oct. 13 (after 8 weeks)	Dec. 8 (16 weeks)	Nov. 10 (12 weeks)
(ii)	Oct. 20 (9 weeks)	Dec. 29 (19 weeks)	Died (Sept.)

It will be noted that response was much slower on 18 hr of light daily than on 15 hr. Thus the extra 3 hr of light may be said to have had an inhibitory effect (alternatively, 3 hr of darkness stimulated!). "Stimulating effects of darkness" in "long-day" animals need not seem very strange; they have been postulated in "short-day" animals (*9*), and the fundamental mechanism is likely to be the same in each. In plants (*10*) quite closely related species may belong on either side of the "long-day"/"short-day" fence.

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AFTER studying the comments of John Hammond, Jr., concerning our recent paper on the role of darkness in sexual activity of the quail (*1*), we conclude that he is making essentially two criticisms. First, in suggesting that darkness may not play an active role

TABLE 1

QUANTITATIVE RESPONSE IN SEXUAL ACTIVITY OF BOBWHITE QUAIL TO DURATION OF INTERRUPTION OF DARK PERIOD

Hours of light	Night interruption	No. of birds	Percentage in full sexual activity after 64 days
17 hr (7:00 A.M.–12:00 M.)	0	9	100
10 hr (7:00 A.M.–5:00 P.M.)	0	10	0
10 hr (7:00 A.M.–5:00 P.M.)	15 min (11:45 P.M.–12:00 M.)	9	33.3
10 hr (7:00 A.M.–5:00 P.M.)	30 min (11:45 P.M.–12:15 A.M.)	9	78
10 hr (7:00 A.M.–5:00 P.M.)	60 min (11:30 P.M.–12:30 A.M.)	10	100

(inhibition, as we reported), he submits that our data could be alternatively interpreted as responses to day length, if one assumes that the day did not necessarily have to be continuous. Second, he suggests that darkness is not necessarily inhibitory, but in some cases may promote sexual activity in animals. We should like to comment on each of these points.

The first criticism seems to us difficult to defend. If the results with quail were to be explained by assuming that the day did not have to be continuous, the additional assumption would have to be made that dark periods as long as 7 hr (the length of summer nights in England) interspersed in the "day" period would not alter the animals' response. We feel that the simpler point of view is the more tenable until the basis for such an additional assumption is established. As direct evidence against Mr. Hammond's suggestion, we have evidence that the response of the quail is quantitatively proportional to the duration of the night interruption, even though the time of night at which the interruption occurs is essentially the same. Results of a sample experiment are shown in Table 1. Such quantitative responses to the duration of the interruption would hardly be expected if the interruption were acting only to extend the day, for the space of time from the beginning of the photoperiod to the end of the night interruption was essentially the same for all groups.

With reference to the second suggestion, that darkness is not necessarily inhibitory in photoperiodic phenomena in animals in general, we hasten to agree. Shull (*2*) showed clearly that wing production in aphids required a period of darkness, the optimum period being 10–14 hr. In *Citellus* full spermatogenesis occurs naturally in the darkness of the hibernation burrow (*3*). Whether darkness is stimulating in this case may be debatable, but it can scarcely be inhibit-

ing. In the case of plants it is well known that a long night either stimulates or inhibits reproduction when applied to short-day or long-day species, respectively (*4*).

The comments of Mr. Hammond are interesting and in our opinion serve to emphasize even further that the experiments in our report are the first to indicate *clearly* that the night or dark period exerts a discrete and specific influence in the photoperiodic responses of higher animals.

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The Languages of the Language of Science

THERE has been some discussion among mathematicians as to the Ph.D. requirements with respect to languages. One faction maintains that the rate of increase of papers published in the Russian language requires a revision of the usual French and German requirement to one that would admit Russian as an alternative at least. Some graduate schools have adopted this modification, and others are considering it. The other faction has said that, since there are still more papers published each year in each of the languages now required than are published in Russian, there is no point in making a change. Their other well-taken point is that in the past the Russian language did not come close to either French or German in quantity of publication. The literature of the past is, of course, of great importance.

We present herewith the results of a survey of mathematics papers, the abstracts of which appeared in *Mathematical Reviews*. Our data represent the classification by language of 34,733 papers. Of this number, 33,769 papers were written in one of seven languages. The other 964 papers were distributed among 23 languages as varied as Chinese, Esperanto, Serbian, and Gaelic.

TABLE 3

	USSR (1946–49)		Worldwide (1940–50)	
	No. of papers	Percentage of total	No. of papers	Percentage of total
Algebra	50	7.1	3,934	11.3
Analysis	425	60.9	14,251	41.1
Applied	51	7.3	9,208	26.5
Geometry	72	10.3	5,040	14.5
Group	54	7.7	1,039	3.0
Topology	47	6.7	1,261	3.6
Total	699	100.0	34,733	100.0

Table 1 is a summary of the languages in which these 34,733 papers were written. It is immediately apparent that English was used for almost half the papers, being over twice as prevalent as French, which ranks second. One reason for the extremely high position of English and the relatively high position of French is that prior to 1947 Russian scientists were given the choice of one language other than Russian into which their papers might be translated for publication. That choice usually went to French or English. It should be noted that, although Spanish and Dutch are included in the table, almost 95% of the papers were written in one of five languages.

Table 2 shows the number of papers written in the several languages in 1940 and in 1950. It also includes the ratio of increase from 1940 to 1950. The total number of papers written during the year has increased by a ratio of 2.38:1, but this does not necessarily mean that there has been that great an increase in papers in the field of mathematics. The number of journals abstracted by *Mathematical Reviews* has also increased since 1940. There is no easy way to determine the validity of Table 2 in view of this circumstance. It is interesting, nevertheless, to note that, with the exception of Dutch, in which the number of papers

TABLE 1

Language	English	German	French	Russian	Italian	Spanish	Dutch	Others	Total
No. of papers	15,789	4450	6722	3043	2652	859	254	964	34,733
Percentage of total	45.5	12.8	19.4	8.8	7.6	2.5	0.7	2.7	100.0

TABLE 2

	English	German	French	Russian	Italian	Spanish	Dutch	Total
1940	1052	365	349	92	145	33	9	2045
1950	2099	729	882	610	423	59	63	4865
Ratio $\frac{1950}{1940}$	1.99	2.00	2.51	6.63	2.92	1.79	7.00	2.38

is not large enough to be significant, the ratio of increase of the number of Russian papers abstracted is considerably higher than those of the other major languages.

In a previous paper (*1*) reference was made to the classification of Russian papers by general field during the years 1946–49. The authors received several communications suggesting that the data would have more significance if compared with the same classification on a worldwide basis. Table 3 presents these data. The differences in percentage need no particular comment except to note that security classification may account for the large differences in the field of applied mathematics.

The inevitable conclusion from the data presented is that the Russian language is gaining more and more significance in the field of mathematics. Whether it is now time for a shift in the Ph.D. requirement is a point for argument, but it appears that some adjustment will have to be made before long.

Even more significant is that the Russian scientist is making tremendous strides, whether we like it or not. Since our survival depends on a correct estimate of the situation, it is time for American scientists to draw their conclusions about the quality of Russian work from other sources than the editorial columns of their newspapers.

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Baule-Mitscherlich Limiting Factor Equation

RECENTLY, in a brief communication to SCIENCE (**115**, 23 [1952]), the author pointed out that Blackman's concept of limiting factors, which is based on Liebig's law, is not valid. Since that communication was submitted, a paper written on the subject by Baule (*Landwirtsch. Jahrb.*, **51**, 363 [1918]) has been studied. In it Baule argues that Liebig's law is invalid, and he presents a general limiting factor equation derived from that of Mitscherlich (*Landwirtsch. Jahrb.*, **38**, 537 [1909]). Baule's paper has apparently been ignored by most English-writing biologists. The most conspicuous case of such omission is that of Van den Hohnert (*Rec. trav. botan. Néerl.*, **27**, 149 [1930]), who carried out experiments designed specifically to elucidate the limiting factor problem but failed to include any consideration of Baule's equation.

The general equation is:

$$E = E_{max}(1 - e^{-0.7x/h_1})\ (1 - e^{-0.7y/h_2})\ (1 - e^{-0.7z/h_3})\ (\ldots)\ (\ldots),$$

where E is the rate of a process influenced by several factors; E_{max} is the maximal rate obtained when all factors are present at optimal intensity; and the x, y, z, etc., are intensities of the separate factors influencing the process. The 0.7 and the h's are constants introduced to facilitate fitting the equation to experimental data.

An inspection of the equation shows that the "slowest" factor does not limit the rate of the process exclusively, but all factors are influential at all times in varying degree, depending on their intensity. This is true except in the special case where a factor has zero intensity. Then the rate is zero, regardless of the intensity of other factors; thus Liebig's law is valid in this special case. The equation predicts, as has frequently been demonstrated experimentally, that when one factor is at a suboptimal intensity, the manipulation of other factors will still produce changes in the rate of the process. An examination of the individual terms of the equation reveals that the manipulation of a single factor, other factors being constant, should yield a logarithmic curve, not a Blackman-type curve. This prediction is also abundantly confirmed by the experimental results obtained by a host of researchers. The equation, therefore, seems to constitute an acceptable expression of limiting factor theory, and deserves more recognition than biologists have accorded it during the 35 years since it was published.

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Fluoridation of Water

WITH reference to page 199 of the Feb. 20, 1953, issue of SCIENCE, stating a resolution was passed by the Subsection on Dentistry (N2) endorsing fluoridation of city water supplies, can you give me any further information as to the disposition of the resolution?

VICTOR E. CARUSO

Wyckoff, New Jersey

On Saturday, December 27, Section Nd adopted the following resolution and directed that it be conveyed to the AAAS for approval and publication:

Be it resolved, That Section Nd (dentistry) convened in annual session in St. Louis December 27 strongly endorsed the fluoridation of city water supplies as a partial preventive of decay of the teeth of children and recommends that all cities and communities having a central water supply adopt this health measure.

Book Reviews

The Chemistry and Physiology of the Nucleus. *Experimental Cell Research,* Suppl. 2, 1952. Proceedings of the Symposium held August, 1951 by the Biology Department, Brookhaven National Laboratory. V. T. Bowen, Ed. New York: Academic Press, 1952. 402 pp. Illus. $7.00.

In this volume are presented the proceedings of a symposium on nuclear chemistry and biology held at the Brookhaven National Laboratory. A list of the contents emphasizes the wide range of interests covered by the symposium:

"Problems in Nuclear Chemistry and Biology" (K. G. Stern); "Interrelations between Nucleus and Cytoplasm" (J. Schultz); "The Role of the Nucleus in Protein Synthesis" (F. Haurowitz and C. F. Crampton); "Nucleoproteins of the Nucleus" (A. W. Pollister); "Quantitative Optical Techniques in the Study of Nuclear Chemistry" (M. J. Moses); "The Lampbrush Chromosomes of *Triturus viridescens*" (J. G. Gall); "The Enzymes of Isolated Nuclei" (A. L. Dounce); "Histochemical Demonstration of Nuclear Enzymes" (A. B. Novikoff); "Evidence for the Polynucleotide Nature of Cysteinylglycinase" (F. Binkley); "Organization and Function of the Inorganic Constituents of Nuclei (of Drosophila larvae)" (D. F. Poulson and V. T. Bowen); "Studies on the Metabolism of the Nucleic Acids" (A. Bendich); "Specificity in the Composition of Nucleic Acids" (G. R. Wyatt); "Chemical Action of X-Rays on Nucleic Acids and Related Substances in Aqueous Systems" (G. Scholes and J. Weiss); "Relationships between Ionizing Radiation, Chromosome Breakage and Certain Other Nuclear Disturbances" (A. H. Sparrow, M. J. Moses, and R. J. Dubow); "Chromosome Metabolism as Shown by Autoradiographs" (S. R. Pelc and Alma Howard); "Effects of Purines and Other Chemotherapeutic Agents on Nuclear Structure and Function" (J. J. Biesele, Ruth E. Berger, Marilyn Clarke, and L. Weiss); "The Effect of Colchicine on the Microscopic and Submicroscopic Structure of the (first maturation division) Spindle (of the oöcyte of *Chaetopterus pergamentaceous*)" (S. Inoué); "Current Status of the Bacterial Nucleus" (E. D. DeLamater, M. E. Hunter, and S. Mudd); "The Origin of Bacteriophage Nitrogen, Carbon, and Phosphorus" (F. W. Putnam); "The Fate of the Infecting Virus Particle (L. M. Kozloff); and "The Biological Nature of the Bacterial Transforming Factors" (R. D. Hotchkiss).

In addition, the value of many of these contributions is enhanced by the inclusion of a report of the subsequent discussion.

Certain of the initial papers, which attempt to reconcile current ill-defined ideas of desoxypentosenucleoprotein structure with biological function, suffer from a surfeit of hypotheses, whereas others merely reiterate the results of work already published. Prominent among the contributions which record new observations are those of Gall and Binkley. The latter describes the isolation from frozen pig kidney of a protein-free polypentosenucleotide fraction that exhibits high hydrolytic enzyme activity against cysteinylglycine and glycylcysteine. The work, which possibly points to a definite function of the pentosenucleic acids, is presented with caution in the form of a progress report, and it is emphasized that it would be premature to ascribe the enzyme activity to the polynucleotide alone.

Novikoff's paper on the histochemical demonstration of nuclear enzymes—largely confined to an extensive consideration of the limitations and sources of error inherent in the Gomori and other techniques for the location of alkaline phosphatase—includes a limited survey of the distribution of 5-adenylic acid (adenosine-5-phosphate) phosphatase, adenosine triphosphatase, "DNA-phosphatase," and succinic dehydrogenase.

Pele and Howard discuss the synthesis of desoxypentosenucleic acid and sulfur-containing protein in the chromosomes of cells from the meristematic tissue of the main root of *Vicia faba* seedlings and show, by experiments in which the growing roots are subjected to irradiation with x-rays, that the synthesis of protein in the chromosomes can occur without a corresponding synthesis of desoxypentosenucleic acid.

The current concept of DeLamater, Hunter, and Mudd that the bacterial nucleus is essentially similar to the nuclei of higher organisms, and contains discrete, countable chromosomes, which undergo a typical mitotic process prior to the division of the cell, is derived solely from the recent extensive investigations of DeLamater and his colleagues, and excludes the equally current concepts held by other bacterial cytologists.

Among the papers of predominant chemical interest, that presented by Scholes and Weiss gives a comprehensive account of the nature of the degradative changes induced in aqueous solutions of nucleic acids by irradiation with x-rays, which lead to an initial depolymerization of the substrates, followed by fragmentation of the polynucleotides and the liberation of inorganic phosphate, ammonia, and small amounts of free purine bases.

Bendich's paper, which gives detailed and critical consideration to the nature of the biosynthesis of the nucleic acids, also points to heterogeneity in constitution, and possibly function, of the desoxypentosenucleic acid of rat tissues. Thus, it is now possible to separate the desoxypentosenucleic acids of the pooled internal organs of adult rats, or regenerating rat liver, into two distinct fractions, which differ not only in their solubilities in 0.87% sodium chloride solution, but also in metabolism and rates of turnover.

Wyatt deals thoroughly with the differentiation of nucleic acids, particularly desoxypentosenucleic acids, by the determination of the relative amounts of the purine and pyrimidine bases. Differences in the proportions of the major bases between one nucleic acid and another, as revealed by analyses carried out in

various laboratories, are considered significant in some cases, but in others no greater than the experimental error. The 5-methylcytosine content, which, when high, tends to be balanced by a reduced amount of cytosine, is significantly different for the desoxypentosenucleic acids of every animal species, and is the same only in desoxypentosenucleic acids derived from different tissues of the same species. The greater constancy of the composition of the desoxypentosenucleic acids isolated from higher organisms, than that from lower ones, apparent from the results thus far available, is considered to be consistent with the concept that the analyses determine the mean composition of a number of gene-specific nucleic acids.

In a critical review of the chemical and photometric evidence leading to the concept of a constant amount of desoxypentosenucleic acid in the interphase nuclei of different somatic tissues of the same species, Pollister justly emphasizes that the apparently constant values obtained are statistical means, and neither procedure excludes the possibility that the nuclear desoxypentosenucleic acid content varies during intracellular metabolism. In this paper attention is also drawn to the high content of nonhistone protein in cell nuclei (provisionally estimated, for example, as 65% of the dry weight of the interphase nucleus of the mammalian liver cell), which differs from cell to cell, and which merits more detailed chemical investigation than it has hitherto received.

Putnam produces evidence to show that most of, if not all the phosphorus of the T7 bacteriophage nucleoprotein is derived from the desoxypentosenucleic acid of the *Escherichia coli* host cell. Synthesis of the phage desoxypentosenucleic acid is preceded by the degradation of the host nucleic acid to oligo- or mononucleotides.

Kozloff presents an interesting summary of evidence to show: (1) an extensive breakdown of the *E. coli* T6r+ and T7 bacteriophages occurs during the reproductive process; (2) the contribution of parent material to the virus progeny is not a specific and obligate part of the reproductive process; (3) the transfer of nitrogen and phosphorus from the parent virus to the progeny involves excessive rearrangements and is largely independent of genetic units. In the subsequent discussion certain of the results and hypotheses presented in the paper are debated with exuberance.

MICHAEL WEBB

Department of Microbiology
Rutgers University

Sir James Jeans: A Biography. E. A. Milne. New York: Cambridge Univ. Press, 1952. 176 pp. Illus. $4.00.

Just before his death in 1950 Milne completed this biography of Sir James Jeans. The biography consists of three parts, the first part being a memoir by S. C. Roberts, of the Cambridge University Press. In this memoir, Roberts describes how he induced Jeans to write *The Universe Around Us*, the first of the series of books meant for the general public in which Jeans so successfully popularized the theories and discoveries of astronomy and physics. Roberts also describes how Jeans met his second wife in the Swiss and Italian mountains, while on holiday.

The main part of the book is Milne's biography. In the first six chapters Milne describes in detail Jeans' life, his academic career, and his career as a writer of popular books. The last six chapters are devoted to a critical account and assessment of Jeans' contributions to science. The bibliography of all Jeans' works is given at the end of the book. In it one finds a list of eight technical books, ten popular books, and 76 research papers, as well as of ten references to abstracts of lectures. From this biography there emerges a picture of Jeans, the man and the scientist, but also a picture of Milne, and finally a picture—and not always a pleasant one—of the atmosphere of British astronomy.

The biographical part falls naturally into six chapters. The first deals with Jeans' boyhood and years in Cambridge, the second with his stay in Princeton, where he was invited as professor of applied mathematics by Woodrow Wilson at the same time as O. W. Richardson, G. Birkhoff, O. Veblen, and Henry Norris Russell. The third chapter deals with the period from 1909–19, during which Jeans probably made his most important contributions to science. The fourth chapter is devoted to the ten years that Jeans was secretary of the Royal Society, and the fifth and sixth chapters deal with Jeans' popular works and the last years of his life. Milne stresses the fact that as a stylist, both in his scientific writings and his popular books, Jeans was outstanding. Before he started writing for the general public, Jeans had gained a place in *The Oxford Book of English Prose*.

In the last part of the biography, Milne discusses critically, sometimes perhaps too critically, Jeans' contributions to science. Again the division in chapters comes naturally, and they deal successively with kinetic problems, rotating masses, star clusters, stellar equilibrium, and Jeans and philosophy.

Jeans' popular books are still fascinating to read, whether or not one agrees with him in all detail, and it is extremely fortunate that we now possess in Milne's biography a fascinating account of this outstanding British scientist. As one can expect from the Cambridge University Press the book is beautifully produced and at a reasonable price.

D. TER HAAR

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The Wiley Bulletin

SCIENCE EDITION

New York — *April 10, 1953*

AFRICA VIEWED IN NEW LIGHT

When H. M. Stanley "discovered" tropical Africa 80 years ago, most of his fellow Americans paid little attention. That it is among the least "known" of all continents is still true. Often lightly passed off as a "backward" area, Africa plays a more important role in our modern life than is realized. Dr. Dudley Stamp, President of the International Geographical Union, while lecturing on "Underdeveloped Areas", found that Africa repeatedly proved an apt example — yet concrete information about this continent was sadly lacking. Out of this realization grew *Africa: A Study in Tropical Development.*

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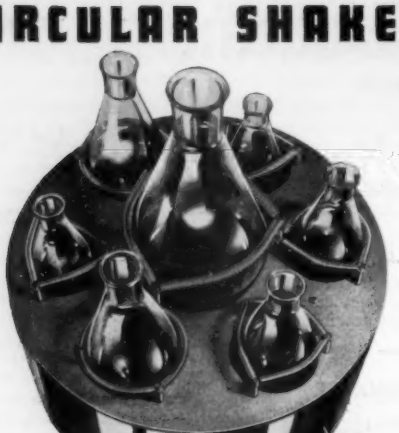

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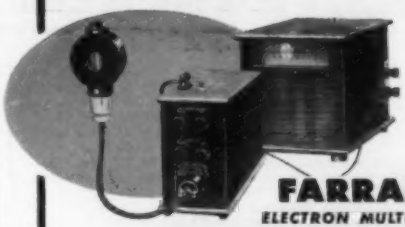

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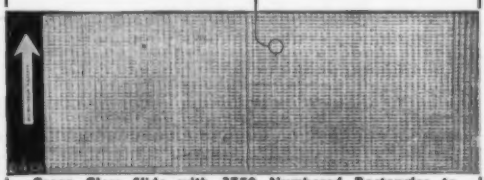

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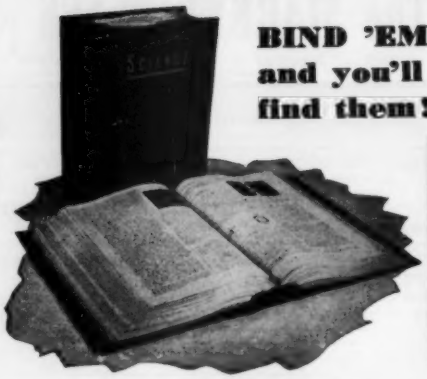

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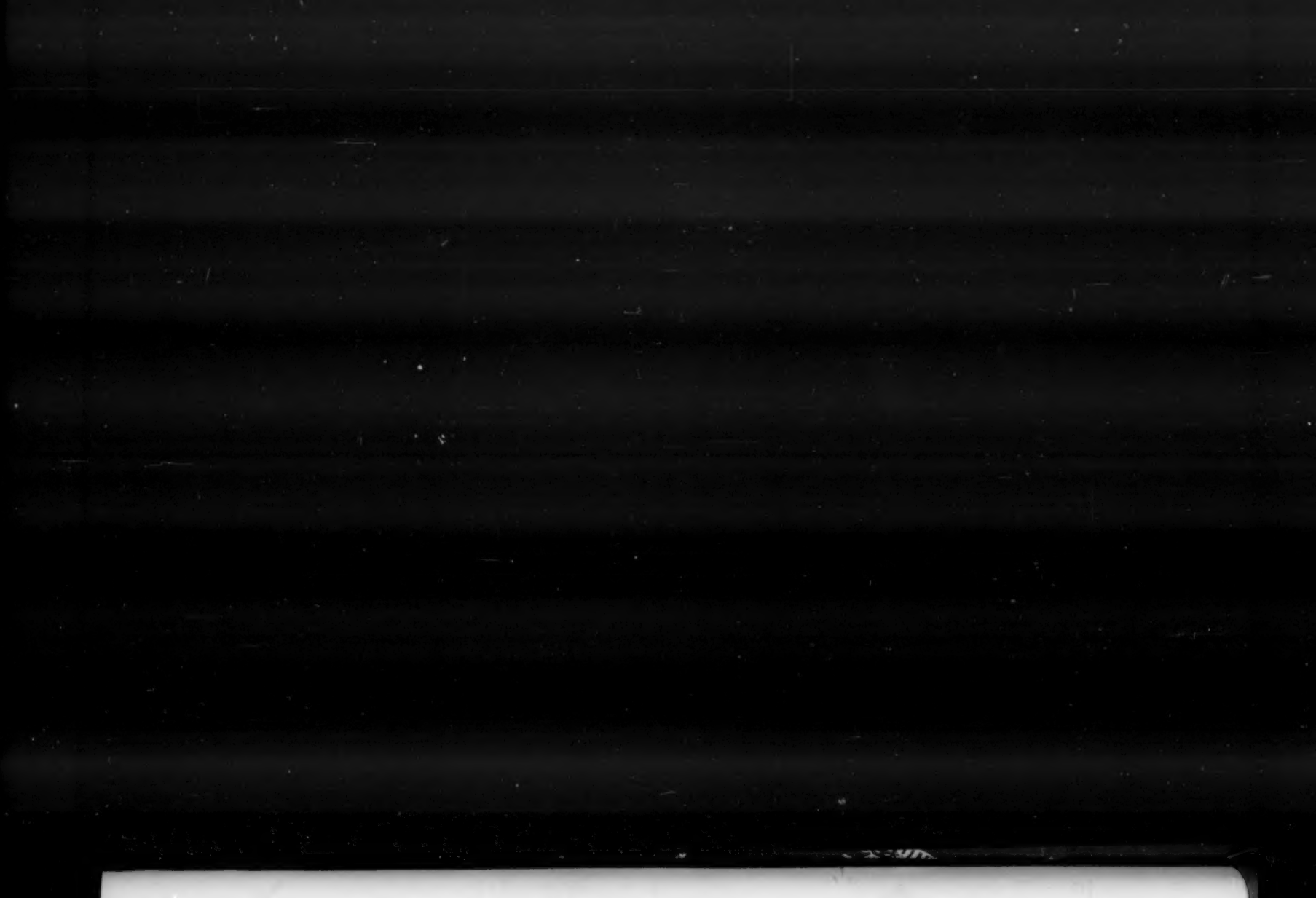
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